Ecological restoration for *SocioBioCotidiano*: Nexus+ in the context of the climate catastrophe in the PAN Lagoas do Sul territory

Restauração ecológica para o SocioBioCotidiano: Nexus + no contexto da catástrofe climática no território do PAN Lagoas do Sul

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ABSTRACT

Nexus+ interrelates water, energy, food, and socio-environmental security, an agenda promoted in the PAN Lagoas do Sul territory through ecological restoration for *SocioBioCotidiano*. In this territory, the portion of the metropolitan region of Porto Alegre and Laguna dos Patos was severely impacted by the floods of 2024. In this context, the objective was to analyse ecological restoration for *SocioBioCotidiano* as a strategy for achieving security in the context of climate emergencies. To this end, documentary and literature analyses were carried out to characterise the climate emergency and analyse the potential for achieving security by species and ecosystems. All ecosystems presented ecosystem services that guarantee security at a local and regional level, contributing to urban territory resilience. The notion of

SocioBioCotidiano presents itself as a regional supply strategy that promotes biodiversity conservation and restoration, climate change mitigation and socio-environmental justice.

Keywords: Water, energy, food and socio-environmental security. Agroforestry systems. Sociobiodiversity products. Pampa. Atlantic Forest.

RESUMO

Nexus+ inter-relaciona as seguranças hídrica, energética, alimentar e socioambiental, agenda promovida no território do PAN Lagoas do Sul por meio da restauração ecológica para o SocioBioCotidiano. Nesse território, a porção da região metropolitana de Porto Alegre e da Laguna dos Patos foi severamente impactada pelas enchentes de 2024. Nesse contexto, objetivou-se analisar a restauração ecológica para o SocioBioCotidiano como estratégia para o alcance das seguranças no contexto das emergências climáticas. Com esse fim, foram realizadas análises documental e de literatura com vistas a caracterizar a emergência climática e analisar o potencial de alcance das seguranças pelas espécies e ecossistemas. Todos os ecossistemas apresentaram serviços ecossistêmicos que garantem as seguranças em nível local e regional, concorrendo para a resiliência dos territórios urbanos. A noção de SocioBioCotidiano se apresenta como uma estratégia regional de abastecimento que promove a conservação e restauração da biodiversidade, a mitigação das mudanças climáticas e a justiça socioambiental.

Palavras-chave: *Seguranças hídrica, energética, alimentar e socioambiental. Sistemas agroflorestais. Produtos da sociobiodiversidade. Pampa. Mata Atlântica.*

1 INTRODUCTION

The Nexus agenda considers the relationship between water, energy and food security to be inseparable (Biggs *et al*., 2015) because the three elements that are at its base, such as water, energy and food, are impacted by the same factors, such as climate change, urbanisation, consumer demand growth, globalisation and natural resource degradation (Hoff, 2011). This agenda has been constructed through various debates and conferences since the end of the 20th century but gained greater momentum on the international agenda after the World Economic Forum Annual Meeting 2008 convened in Davos (Endo *et al*., 2017). According to Coutinho *et al*. (2020), the Nexus approach has more recently included the concept of socio-environmental security, which includes inherent vulnerabilities of the territory in relation to extreme weather events that can trigger catastrophes. The inclusion of this fourth dimension makes up Nexus+.

Water, energy, food and socio-environmental security are directly related to the United Nations 2030 Agenda, which recognises 17 Sustainable Development Goals (SDG). According to Rabelo *et al*. (2018), SDG 1 (No Poverty), SDG 2 (Zero Hunger and Sustainable Agriculture) and SDG 3 (Good Health and Well-Being) correspond to SDGs related to basic human needs. The Nexus Agenda is strongly related to these SDGs and is competing to meet these needs. Water security is strongly linked to SDG 6 (Clean Water and Basic Sanitation). Energy security is related to SDG 7 (Affordable and Clean Energy) and SDG 8 (Decent Work and Economic Growth). SDG 4 (Quality Education) is associated with understanding the relationships between the three security goals.

SDG 13 (Climate Action), SDG 14 (Life Below Water) and SDG 15 (Life on Land) are related to the dimension of socio-environmental security as a basis for territory sustainability and resilience. This degraded territories' capacity can be restored through ecological restoration, with the United Nations General Assembly declaring 2021–2030 the UN Decade of Ecosystem Restoration (FAO; SER; IUCN CEM, 2023), considered a fundamental tool to limit or reverse the acceleration of climate change and re-establish an ecologically healthy relationship between nature and culture.

In Brazil, the Ministry of Science, Technology and Innovation has promoted the Nexus agenda linked to the SDGs since 2017 through a public call that financed 30 projects developed in all biomes, except the Amazon biome (Call MCTIC/CNPq (a government agency of the Ministry of Science and Technology of Brazil) 20/2017). In Rio Grande do Sul, four projects were developed linking security with ecological restoration and agroforestry systems in the Atlantic Forest and Pampa biomes, namely, *Nexo Pampa* (Marev (non-profit entity)/*Embrapa Clima Temperado* (research institute in Rio Grande do Sul)), Conexus (Neprade/UFSM (scientific research institute in Santa Maria, Rio Grande do Sul)), *Rota dos Butiazais* (*Embrapa Clima Temperado*) and PANexus (AsSsAN *Círculo*/UFRGS (institution that aims to promote teaching, research and extension activities on agroecology, sovereignty and food and nutritional security in Latin America and interfaces)) (Guarino *et al*., 2023). The concept that supports the term PANexus, which names the project "*Governança da sociobiodiversidade para as seguranças hídrica, energética e alimentar na Mata Atlântica Sul*" (Governance of sociobiodiversity for water, energy and food security in the Southern Atlantic Forest), refers to the integration of the action of the Brazilian National Action Plans for Endangered Species (PAN - *Planos de Ação Nacionais para Espécies Ameaçadas de Extinção*), or with the Nexus agenda, referring to the challenge of promoting the four securities in the territories of sandbanks and araucaria forests in southern Brazil (Coelho-de-Souza, 2020).

This project focused on understanding Nexus+ in the context of the territory of the National Action Plan for the Conservation of Lake and Lagoon Systems in Southern Brazil (Cepsul/ICMBio (research institute in Itajaí, Santa Catarina)), PAN Lagoas do Sul (Steenbock, 2021). It was assumed that security is guaranteed when a territory is capable of providing ecosystem services for support, regulation, provision and human and environmental health that guarantee each individual and family access to water, energy and food in quantity and quality, respect cultural practices and are socially, economically and environmentally sustainable. In this context, biodiverse agroforestry systems, inserted in native ecosystems, promote water security due to their capacity for water percolation in the soil, promoting: aquifer recharge; filtering of soil sediments, avoiding silting and protecting the quality of water bodies; maintenance of riparian forests around watercourses, maintaining the structure of water bodies and protecting their banks.

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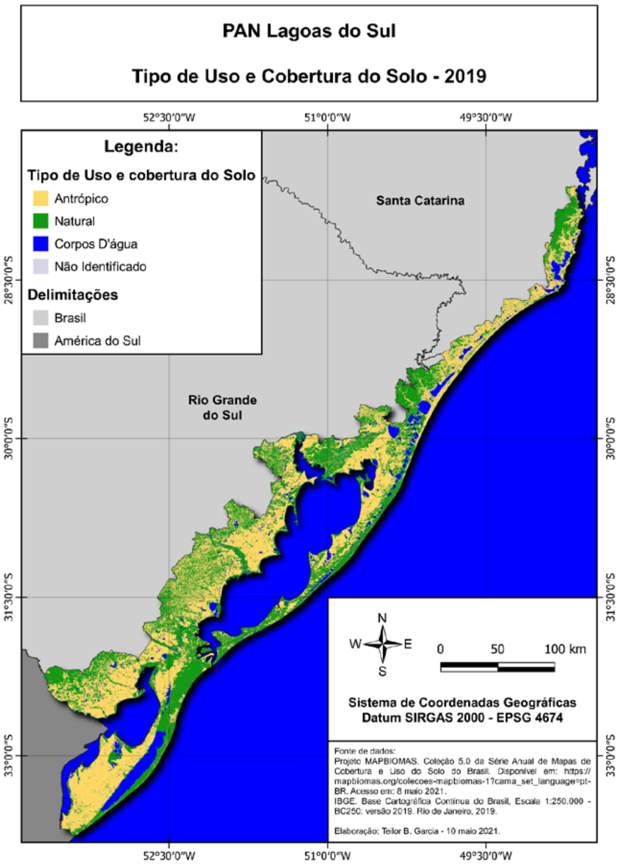

Figure 1 – Lagoas do Sul National Action Plan (PAN Lagoas do Sul) area map.
Source: Prepared by Garcia (2021).

Energy security is provided by firewood from agroforestry systems and native ecosystems, which is related both to thermal security through heating homes and to the provision of energy for cooking food in rural and urban spaces. Food and nutritional security are provided through sociobiodiversity products for food use that allow "regular and permanent access to quality food, in sufficient quantity, without compromising access to other essential needs based on health-promoting dietary practices that respect cultural diversity and are environmentally, culturally, economically and socially sustainable" (Brasil, 2006). Food security is related to food supply systems, where agroforestry systems are part of the production link, which is connected to consumption.

As Brazil has more than 80% of its population living in urban centres, consumers' connection with native ecosystems and their understanding of their importance in the context of the climate crisis is quite tenuous. In this regard, the concept of *SocioBioCotidiano* (Sociobiodiversity, Daily living) is relevant as it is defined as the conscious consumption of sociobiodiversity products in people's and families' daily lives, strengthening supply networks based on the principles of sociobiodiversity chains (Brazil, 2009), in line with SDG 12 (Responsible Consumption and Production). *SocioBioCotidiano* is a strategy for conserving biodiversity, combating poverty, food and nutritional security, and preventing and mitigating the effects of climate change, through regionalised and decentralised supply systems, seeking to position sociobiodiversity in central actions for developing megabiodiverse countries like Brazil as recommended by the Brazilian Platform for Biodiversity and Ecosystem Services (Joly *et al*., 2019).

The PAN Lagoas do Sul territory is home to the Atlantic Forest and *pampa* biomes (pastoral region of hilly plains located in southern South America), in addition to the coastal-marine system with the presence of a string of lagoons, such as Laguna dos Patos, which makes up a complex hydrological system that receives the flow of large rivers that cross the state. The metropolitan region of Porto

Alegre is located in this part of the territory. In May 2024, the state of Rio Grande do Sul was hit by intense rains with large volumes of water and long duration, being a climate catastrophe, impacting an area equivalent to the territory of the United Kingdom (Clarke *et al*., 2024).

In Rio Grande do Sul, the climate crisis has shown that 4.12% of the territory (1.16 million hectares) are areas of permanent preservation and legal reserve that are degraded (Instituto Escolhas, 2023), which are substantial for ecosystem resilience. These areas have the potential to be re-established through ecological restoration for *SocioBioCotidiano*, contributing to achieving water, energy, food and socio-environmental security, in addition to preventing and mitigating climate emergencies, which are a reality in the PAN Lagoas do Sul territory. Natural and naturalised ecosystem conservation and restoration play a prominent role in long-term solutions to mitigate the impacts of flooding, especially through their effects on attenuating surface runoff. Thus, just as the causes of floods and their effects are interconnected in geographic space, solutions must be planned within the scope of territorial planning that explicitly considers the chain of interconnected hydrological processes in rural and urban territories (AKTER, 2018; MISHRA *et al*., 2018; O'DONNELL; THORNE, 2020; ZIMMERMANN *et al*., 2016).

In this context, this article aims to analyse ecological restoration for *SocioBioCotidiano* as a strategy to achieve water, energy, food and socio-environmental security in facing the climate catastrophe in the PAN Lagoas do Sul territory (Figure 1). The methodology consisted of a documentary analysis of media outlets and public databases with a view to characterising the climate emergency in May and June 2024 in Rio Grande do Sul. A literature review was used to analyse PAN Lagoas do Sul species' and ecosystems' contribution to achieving Nexus+ and *SocioBioCotidiano*, whose method is described in Section 3.

The article initially characterises the climate catastrophe dynamics based on aspects of the function of native ecosystems and hydrological cycle in the lake-river Guaíba and Laguna dos Patos complex, justifying the demand for ecological restoration for *SocioBioCotidiano* as a strategy to face the climate emergency. This study presents below sociobiodiversity species with the potential for ecological restoration for *SocioBioCotidiano* in different ecosystems. Subsequently, the contribution of ecosystem characteristics is discussed in the context of water, energy, food, and socio-environmental security, considering the capacity of ecosystem services provided in facing climate emergencies and in the relationship between rural and urban areas. Finally, final considerations are presented.

2 CLIMATE CATASTROPHE DYNAMICS: ASPECTS OF THE HYDROLOGICAL CYCLE AND FUNCTION OF NATIVE ECOSYSTEMS IN LAKE-RIVER GUAÍBA AND LAGUNA DOS PATOS COMPLEX

The climate catastrophe in Rio Grande do Sul that severely affected the metropolitan region of Porto Alegre and the banks of Laguna dos Patos is the result of a series of synergistic factors. Cold air masses from the south met with warm air masses from the central-west, southeast and south, which kept the rains in Rio Grande do Sul for more than 15 days. This climate situation, associated with the relief and hydrography in the region, was aggravated by human interference in land use, contributing to the rapid accumulation of high volumes of water in lake-river Guaíba and Laguna dos Patos.

Wetland, soil and forest destruction, through native vegetation suppression from the highest altitudes, where headwaters of rivers are located and, in particular, in risk areas such as hillside areas, riparian forests, floodplains and lake shores, associated with intense urbanisation, prevented processes such as water percolation in the soil and water retention in ecosystems with a sponge effect, such as *Delta Jacuí* (hydrographic set of sixteen islands, canals, swamps and ponds in the metropolitan region of Porto Alegre) and wetlands, from fulfilling their ecological function.

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Torrential rains resulted in landslides, floods, and total flooding of the city of Eldorado do Sul, partial flooding of the capital Porto Alegre and several cities along the rivers that flow into lake-river Guaíba and on the banks of Laguna dos Patos. The capital collapsed, and essential services such as electricity, water supply, and the internet were suspended. Roads were closed, and internal roads were obstructed in the city. Moreover, schools and universities suspended their activities, and the airport and bus stations were paralysed. There were 169 official deaths, with 2,345,400 people affected, 581,638 people displaced, 77,729 people rescued from their homes, and 12,527 animals rescued and housed in shelters (Carta das Agroflorestas, 2024).

The climate catastrophe in the city of Porto Alegre exceeded the last flood of lake-river Guaíba, which had occurred in 1941, when it reached a water level of 4.76 meters in 20 days, measured at the port pier, generating a similar collapse scenario. In 2024, the flood level reached 5.35 meters in seven days, a consequence of the rapid accumulation of high volumes of water in lake-river Guaíba and Laguna dos Patos. This unprecedented catastrophe destroyed a large part of the state's infrastructure, especially in the metropolitan region, drastically affecting the state's economy, with estimates of economic losses in municipalities of around 9.6 billion *reais* (Brazilian currency), losses in housing of around 4.6 billion *reais* and 2 billion *reais* in agriculture (Carta das Agroflorestas, 2024).

This acute situation, together with the context of climate change, in which extreme weather event frequency and intensity are expected to increase, leads to great vulnerability in accessing and guaranteeing Nexus+ security, with impacts on human health and ecosystems (Coutinho *et al*., 2020). This situation especially affects the most vulnerable populations, such as peripheral populations, peasant family farmers, and traditional peoples and communities, who, in many cases, have practices in their ways of life that strengthen ecosystem resilience. However, because their territories are quite small in relation to land use that contributes to climate disasters, such as monocultures, without respect for permanent protection areas and legal reserves, ecosystem services in their territories do not have the power to prevent the effects of climate catastrophes and, as a result, populations become victims of climate injustice.

The PAN territory has urban and peri-urban centres, the metropolitan region of Porto Alegre, seaside resorts, and rural areas dedicated to agricultural production, fishing, clay extraction and conservation units. In the urban context, social problems associated with the presence of large ports in the cities of Rio Grande and Imbituba, real estate development in the seaside resorts, as well as the dynamics of the metropolitan region of Porto Alegre, such as high rates of unemployment and violence, generating social insecurity, excel. This complex problem also generates food and nutritional insecurity, mainly due to lack of income and, in many cases, lack of access to food, where energy insecurity stands out, mainly in relation to the high prices of cooking gas and electricity, a problem present throughout the territory (Coelho-de-Souza *et al*., in press).

Water insecurity is also an imminent condition for the metropolitan region, not because of the quantity of water available but because of the quality for consumption. The rivers that flow into *Delta Jacuí Deta* and supply a large part of the metropolitan region receive all the industrial waste and sewage from the Vale dos Sinos region that is taken to Laguna dos Patos. In addition to this, there is the challenge of the quality of available water and the lack of basic sanitation in some locations (Coelho-de-Souza *et al*., in press).

Despite these serious urban problems affecting the metropolitan region, the PAN territory is eminently rural, considering its geographical dimensions. It presents different socioeconomic and cultural dynamics associated with: a) maritime, estuarine and lagoon environments, where fishing is established; b) wetlands, lagoons and humid areas with dynamics associated with rice production; c) *butiá* (South American fruit) trees and areas of dry and wet soils, aimed at livestock and *butiá* production; d) forests associated with agroforestry management, indigenous people and participatory management of conservation units; e) areas of sandbanks and forests managed by *quilombolas* (common name for slaves who took refuge in *quilombos*, or descendants of black slaves whose ancestors, during the period of slavery, fled from sugar cane mills, farms and small properties where they performed various manual labour tasks to form small villages called *quilombos*) in their territories and gardens. In this rural environment, traditional agricultural crops are being replaced by soybeans and pine and eucalyptus forestry, and artisanal fishing spaces are being subsumed by industrial fishing (Coelho-de-Souza *et al*., 2020).

In this context, ecological restoration for *SocioBioCotidiano* through biodiverse agroforestry systems, in addition to providing the four securities related to Nexus+, also promotes ecosystem services for biodiversity conservation, allowing the connection of gene flows maintained by pollinators and dispersers. At the landscape level, they constitute wildlife corridors, promoting the contribution of organic matter to terrestrial food chains and water bodies through riparian vegetation. The capacity to maintain native vegetation, together with Nexus+ security promotion for humans, contributes to preventing and mitigating the effects of climate change by reducing greenhouse gas emissions and ecosystem resilience (Millennium Ecosystem Assessment, 2005).

Native ecosystems, especially the activities of their biodiversity, provide a set of ecosystem services, such as support services (generation and maintenance of biodiversity, including genetic diversity and evolutionary processes of adaptive capacities, primary production, soil formation, etc.), regulation services (climate, quantity and quality of water, atmospheric gases, etc.), provision services (food, drinking water, forage, firewood, etc.) and cultural services (inspiration, aesthetics, religion, recreation, etc.) (Millennium Ecosystem Assessment, 2005).

Ecological restoration is defined as the process of assisting in the recovery of an ecosystem that has been degraded, damaged or destroyed, enabling it to improve its adaptation to local and global changes as well as the persistence and evolution of its constituent species, using native ecosystems as reference models, including many traditional cultural ecosystems. Ecological restoration can be undertaken for many reasons, including restoring ecosystem integrity and addressing specific cultural, socioeconomic, and ecological values that can foster greater socioecological resilience. This requires the involvement of communities, businesses, governments, educators, and land managers in ecosystem restoration decisions and practices (Gann *et al*., 2019).

In this regard, acknowledging available traditional and local scientific knowledge is fundamental. Thus, ecological restoration can also be included in ecosystem management practices that aim at native ecosystem conservation and sustainable use, or it can complement other conservation activities and nature-based solutions. Indigenous peoples and local communities (rural and urban) can benefit from a restoration that values cultures, traditional practices and food production (e.g., fishing, hunting and gathering for subsistence) based on nature. Furthermore, restoration can provide short- and long-term employment opportunities for local stakeholders, creating positive ecological and economic feedback loops (Gann *et al*., 2019).

In this context, ecological restoration for *SocioBioCotidiano* stands out as a strategy for permanent preservation area and legal reserve restoration in these territories. Hence, terrestrial ecosystems and species of sociobiodiversity in the PAN Lagoas do Sul territory were identified and characterised with the potential to strengthen resilience to address climate change, presented and analysed in the following section.

3 SOCIOBIODIVERSITY SPECIES WITH ECOLOGICAL RESTORATION POTENTIAL FOR *SOCIOBIOCOTIDIANO* IN DIFFERENT ECOSYSTEMS

The identification and characterisation of terrestrial ecosystems with potential for ecological restoration for *SocioBioCotidiano* of the PAN Lagoas do Sul territory was carried out based on Brack

(2009) and Waechter (1985), resulting in six ecosystems, which were characterised in Figure 2, such as wet grasslands, dry sandy soils, with and without *butiá* trees, wetlands, swamp forest, sandy forest and lowland dense rainforest (a type of lush tropical forest that occurs in Amazon regions and the Atlantic Forest coastal zone).

F D B E C C E C C B A Dunes

Figure 2 – Schematic profile of vegetation in the northern coastal region of Rio Grande do Sul representing the ecosystems present in the PAN Lagoas do Sul territory
Source: Prepared by Claudio Leme based on Brack (2009).

A - Wet grasslands
B - Dry sandy soils with and without *butiá* trees
C - Wetlands
D - Swamp forest
E - Sandy forest
F - Lowland dense rainforest

The selection of sociobiodiversity species with potential to compose agroforestry systems was carried out based on the Rio Grande do Sul Wood Project (Reitz *et al*., 1983), list of native trees of Ri Grande do Sul (FZB), Plants for the Future - Southern Region (Coradin; Siminski, 2011), based on the following criteria: a) occurrence in the different terrestrial ecosystems of PAN Lagoas do Sul; b) identification of traditional uses and association with multiple uses; c) different forms of life; d) function in biodiverse agroforestry systems. The occurrence of species in ecosystems was consulted in the literature, based mainly on Brack (2009), Coradin and Siminski (2011), De Barcellos and Falkenberg (1999) and Waechter (1985). The ecosystem services provided by ecosystems were characterised based on the literature and expressed through schematic representations relating ecosystems, species, and categories of use for *SocioBioCotidiano* and ecosystem services.

Wet grasslands occur in regions of depressions or floodplains with rapid drainage characteristics, although some remain waterlogged for a longer period of time (Figure 3) (Brack, 2009). Sometimes, they are interrupted by drainage channels, which facilitate the flow of water caused by heavy rains (Brack, 2009). Because they have this characteristic, it is possible to observe in these ecosystems the species belonging to the family *Cyperaceae* (Waechter, 1985), represented mainly by the genera *Cyperus* sp., *Eleocharis* sp., *Fimbristylis* sp., *Rhynchospora* sp. Other species found are *cruz-de-malta* (*Ludwigia* spp.), *tibouchina-do-banhado* (*Tibouchina asperior*), hairy cowpea (*Vigna luteola*), *marcela* (*Achyrocline satureoides*) and southern giant horsetail (*Equisetum giganteum*), many of them with different uses, such as medicinal. Wet grasslands also have great forage potential, with natural pastures composed mainly of grasses and legumes (Waechter, 1985). On the edges of swamp forests in contact with wet grasslands, it is possible to find cockspur coral tree (*Erythrina crista-galli*).

Although wet grasslands of southern sandbanks contain many plant species with significant forage value, today, many of the floodplain areas that were previously used for beef cattle farming have been leased for planting irrigated rice (IBGE, 2010). This conversion of land use from coastal soils to cultivating rice and other agricultural species has major impacts on native vegetation, including its significant reduction (Bonilha, 2013). In the coastal soils of the state of Rio Grande do Sul, beef cattle farming, in most cases, uses natural pastures or fallow rice areas to feed the herd (Bonilha, 2013; IBGE, 2010). However, this system (rice/livestock) has been replaced by soybean production in the summer and ryegrass production in the winter as pasture for cattle (Bonilha, 2013).

It is worth mentioning that beef cattle farming in the state of Rio Grande do Sul has its origins in the early occupation of the agrarian space of Rio Grande do Sul and is a fundamental activity for society's constitution in both economic and sociocultural aspects (Porto *et al*., 2010). Family cattle farmers can be characterised as small rural producers who have a significant part of their monetary income coming from the raising and sale of cattle and sheep (Patrocínio, 2015). Furthermore, family livestock farmers have diverse knowledge about the environment on which they depend, which is reflected in their cultural practices and traditional management of plant species present in diverse environments, including wet grasslands. Many people still practice subsistence farming, saving and using native seeds passed down from generation to generation, which contribute to families' food and nutritional security. However, family livestock farmers cannot be considered a homogeneous group, as there are differences in the way they conduct their activities due to the diversity of ethnic origins, religious beliefs, colonisation, dominant management practices, distance from the rural community to which they belong, among other factors (Patrocínio, 2015).

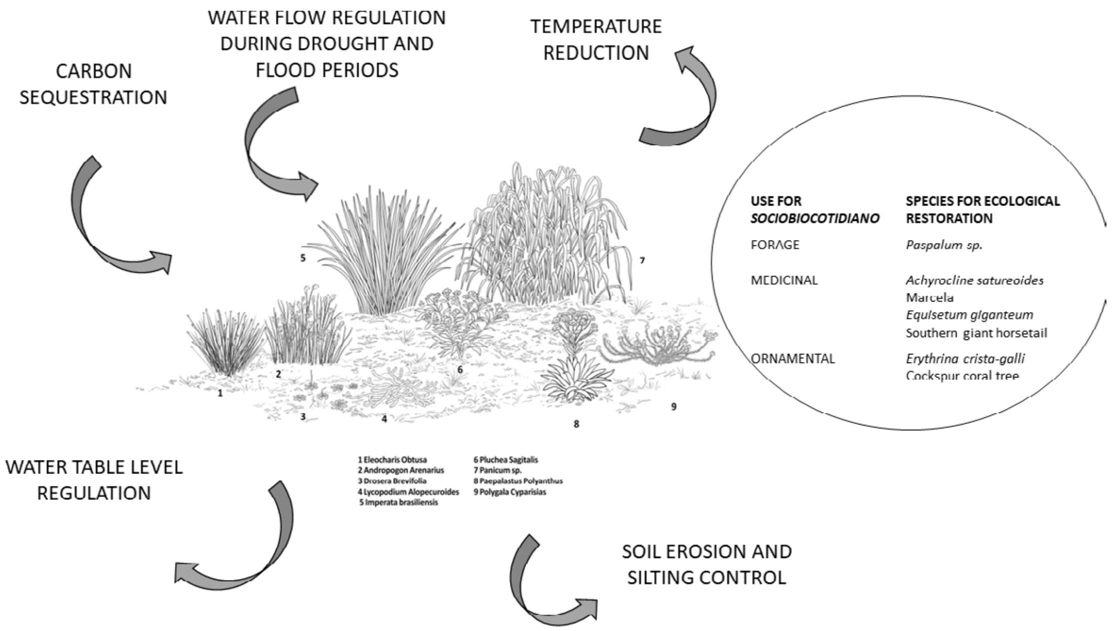


Figure 3 – Ecosystem services provided by wet grasslands with emphasis on species for ecological restoration for *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

Dry coastal sandy soils (Figure 4) occur just after frontal dunes, in the ocean-continent direction, on relatively flat terrain under small dunes (Brack, 2009). They have good water drainage capacity and may be more or less influenced by marine salinity, depending on their proximity to the sea. They may be associated with isolated woods and *butiá* trees, and their area may decrease considerably during the rainy season due to the increase in the level of lakes and lagoons and the coast flat relief (Waechter, 1985). Dry sandy soils, as well as wet sandy soils, have great potential for grazing management with cattle due to the presence of a wide variety of forage species, especially legumes and grasses (Waechter, 1985) of the genera *Eragrostis sp, Panicum sp., Paspalum sp.*, among others (Brack, 2009).

In dry sandy soils, there are also park-like formations, with a large number of *butiá* arranged sparsely or more or less grouped together (Waechter, 1985). It generally consists of the species *Butia odorata* (middle and southern coast of Rio Grande do Sul, also occurring on the northern coast of Rio Grande do Sul) and *Butia catarinensis* (northern coast of Rio Grande do Sul). However, *butiá* trees are more typical of the southern coast of Rio Grande do Sul, and on the northern coast, they generally occur associated with the arboreal vegetation that makes up sandbank forests (Waechter, 1985).

Along the dry sandy soils furthest from the sea, there tends to be occupation by woody plants, forming shrubby vegetation or thickets composed of small trees (Brack, 2009). Among the species that can reach tree size in this environment are *capororoquinha-da-praia* (*Myrsine parvifolia*) and crested eagle (*M. guianensis*), *guamirim* (*Eugenia hiemalis*), camboim (*Myrcia cuspidata*), *tuna* (*Cereus hildemannianus*) and *carobinha* (*Jacaranda puberula*). In this same environment, it is possible to recognise some of the most common shrub, herbaceous and epiphytic species, such as drooping prickly pear (*Opuntia monacantha*), passion fruit (*Passiflora edulis*), *bananinha-do-mato* (*Bromelia antiacantha*), *bromélia-da- restinga* (*Vriesea friburgensis*), *orquídea-da-praia* (*Epidendrum fulgens*), *cipó-imbé* (*Philodendron bipinnatifidum*), glory bush (*Tibouchina urvilleana*), *topete-de-cardeal* (*Calliandra tweediei*), among others. In forests that have undergone human intervention, such as burning or deforestation for agricultural activity, it is possible to observe the formation of brooms, which arise from a regeneration process and which present pioneer species that occur in altered sandy terrains, such as broadleaf hopbush (*Dodonaea viscosa*) and *alecrim-do-campo* (*Baccharis dracunculifolia*) (Brack, 2009).

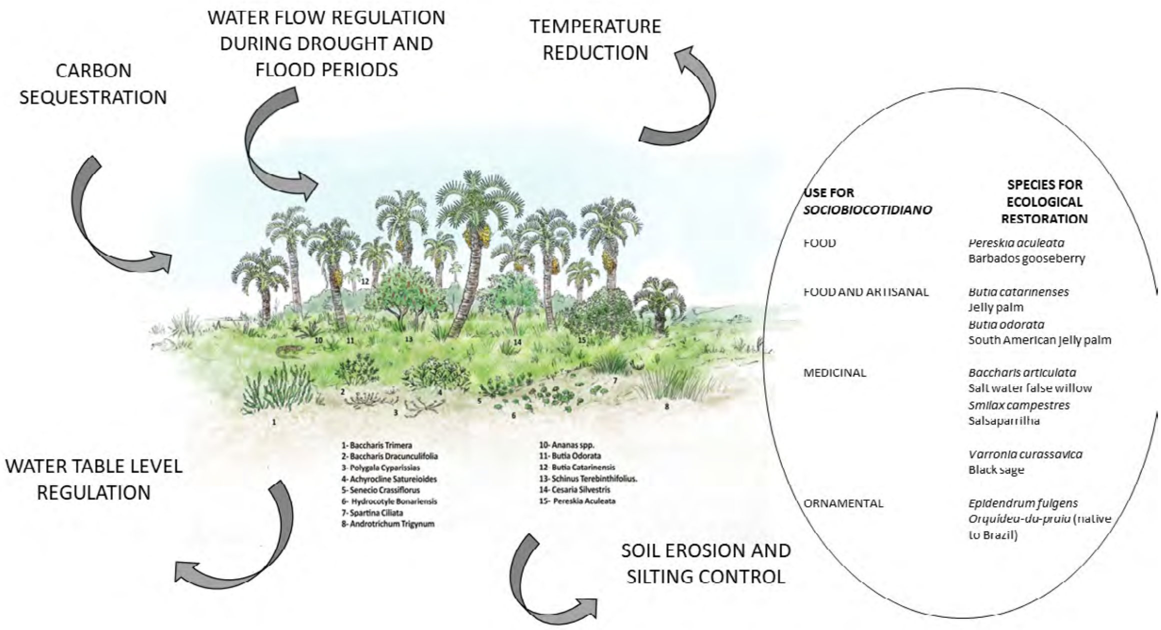


Figure 4 – Ecosystem services provided by dry sandy soils with butiá trees with emphasis on species for ecological restoration for *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

Wetlands (Figure 5) are very heterogeneous, and there may be differences in physiognomy and floristics depending on the degree of drainage and the stage of succession in which they are found (Waechter, 1985). However, in general, they can be considered permanently or periodically flooded areas with waterlogged soils and a large accumulation of organic matter originating from plant remains. Wetland waters can be fresh, brackish or salty, and they have communities of plants and animals adapted to their dynamics. In the coastal plain, these areas are affected by fluctuating water levels in the surrounding water bodies (Schäfer *et al*., 2017). Wetlands are protected by laws that seek to ensure their preservation due to the aquatic life they shelter and the ecosystem services they provide. One of the main threats to these ecosystems in the coastal plain is their destruction due to landfills for urban expansion (Castro; Mello, 2016). The dynamics of wetlands involve the storage and filtration of water during periods of flooding, gradually replenishing watercourses and helping to retain them. Therefore, we can list water storage, water purification, groundwater recharge, sediment retention, reduction of extreme river flow situations, and breeding and feeding sites for many species as the main ecosystem services promoted by wetlands (Schulz *et al*., 2021).

Concerning vegetation, in areas with longer flooding periods, there is a predominance of aquatic macrophytes (Cordazzo; Seeliger, 1988; Irgang *et al*., 1984; Irgang; Gastal Jr., 1996), which can be emergent, amphibious, floating or submerged (de Barcellos; Falkenberg, 1999). Some species found in wetlands are southern cattail (*Typha domingensis*), California bulrush (*Schoenoplectus californicus*), chairmaker's bulrush (*Schoenoplectus americanus*), *margarida-do-banhado* (*Senecio bonariensis*), sword plant (*Echinodorus grandiflorus*), *tibuchina-do-banhado*$_{[gp2]}$ (*Tibouchina asperior*) (Brack, 2009).

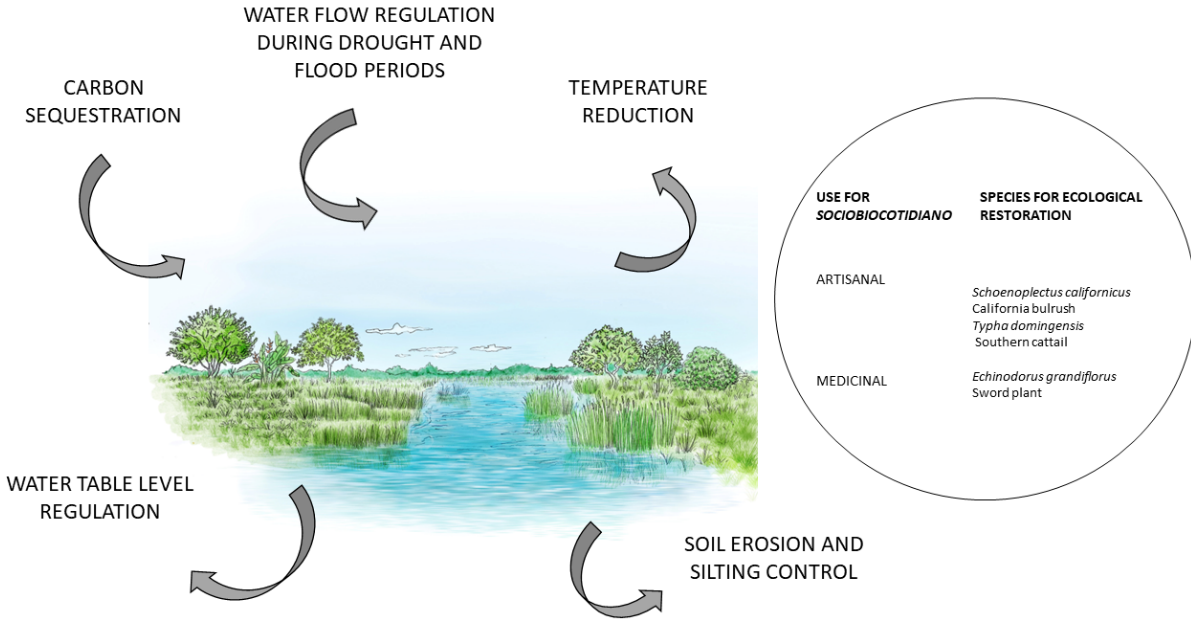


Figure 5 – Ecosystem services provided by wetlands with emphasis on species for ecological restoration for *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

Swamp forests (Figure 6), also known as swamp forests, are forest communities that develop continuously throughout the Coastal Plain of Rio Grande do Sul. (Waechter; Jarenkow, 1998). They are characterised by poorly drained soil, often shallow, acidic, dark grey in colour and with a large accumulation of organic matter (Brack, 2009). The height of their vegetation can reach about 15 meters, where it is possible to find tree and shrub species tolerant to humid and waterlogged soils, in addition to a wide variety of epiphytes and some palm trees (Brack, 2009). The richness and abundance of plant species in swamp forests changes according to latitude, with a decrease in specific diversity from north to south (Waechter, 1985).

In the herbaceous layer, there are shade-tolerant bromeliads and even some aquatic plants. Among the tree species, shortleaf fig (*Ficus cestrifolia*) stands out, whose size can reach about 20 meters in height, with emphasis on its wide canopy coverage, which is covered by a wide variety of epiphytes (Brack, 2009). Below it, there are several species, several of which have different possibilities for use, such as queen palm (*Syagrus romanzoffiana*), ambay pumpwood (*Cecropia pachystachya*), *ipê-amarelo-do-brejo* (*Handroanthus umbellatus*), *palmeira-juçara* (*Euterpe edulis*), *tucum* (*Bactris setosa*), *guaricana-do-brejo* (*Geonoma schottiana*) and Cattley guava (*Psidium cattleyanum*) (Brack, 2009). Its understory may feature tree fern species such as *xaxim-de-espinho* (*Alsophylla setosa*), or shrub species such as *xaxim-do-brejo* (*Blechnum sp.*), and it is also common to find, on the north coast, *bananeira-do-mato* (*Heliconia velloziana*), an herbaceous species with great ornamental potential (Brack, 2009), cockspur coral tree (*Erythrina crista-galli*), a tree with ornamental flowers, and myrtaceae such as *batinga* (*Eugenia uruguayensis*) and *murta* (*Blepharocalyx salicifolius*).

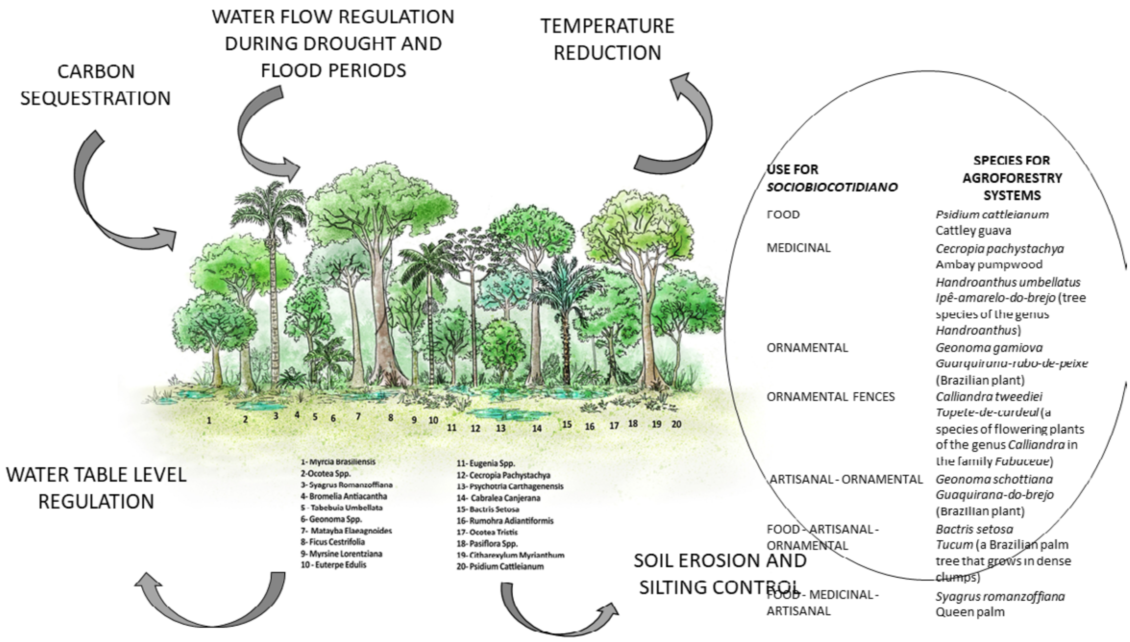


Figure 6 – Ecosystem services provided by swamp forests with emphasis on species for agroforestry systems for *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

Sandy forests (Figure 7) are recognised by forest patches located in sandbanks parallel to the sea or lagoons or in the form of isolated woods (Brack, 2009) and differ from swamp forests mainly due to their well-drained soil. One of the main characteristics of the vegetation of sandy forests is the hardening of the species' tissues, as well as the presence of thorns, reduction of leaves and a glossy surface on the upper sides of the leaves, with the aim of reflecting sunlight and avoiding damage to their internal tissues (Brack, 2009).

In the sandy forest, shortleaf fig (*Ficus cestrifolia*) is found, which emerges from the vegetation canopy, sheltering a great diversity of epiphytes. In the sandy forest, there are several species with multiple uses, such as food, timber, ornamental, and medicinal, among others. The vegetation arrangement in sandy forests has several strata, finding crested eagle (*Myrsine guianensis*), *canela-ferrugem* (*Nectandra oppositifolia*), queen palm (*Syagrus romanzoffiana*) and pacara earpod tree (*Enterolobium contortisiliquum*) in the upper arboreal stratum. Myrtaceae of the genera *Eugenia* sp., *Psidium* sp., *Myrcia* sp., *Myrciaria* sp., in addition to *chá-de-bugre* (*Casearia sylvestris* sp.), are found in the middle arboreal stratum. *Bananinha-do-mato* (*Bromelia antiacantha* sp.) and *orquídea-da-praia* (*Epidendrum fulgens* sp.) are present in the herbaceous layer. On the edges are Brazilian cherry (*Eugenia uniflora*), *tuna* (*Cereus hildemanianus*) and *trepadeira japecanga* or *salsaparrilha* (*Smilax campestris*). It is common for some species considered epiphytic to occur in the soil due to their high drainage and light penetration (Waechter, 2009).

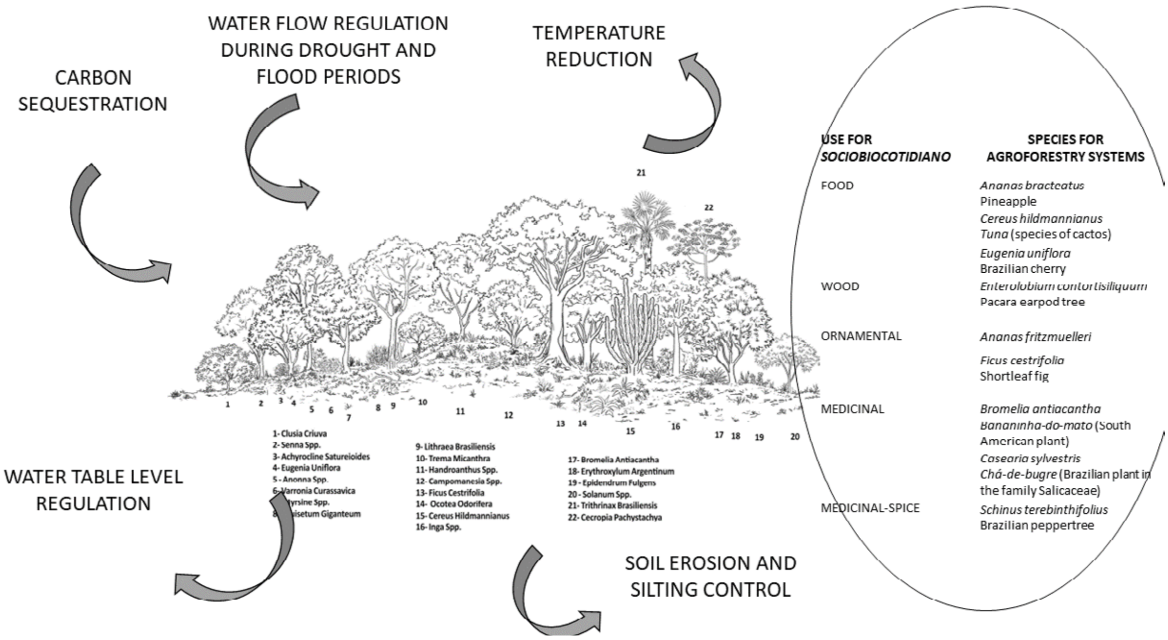


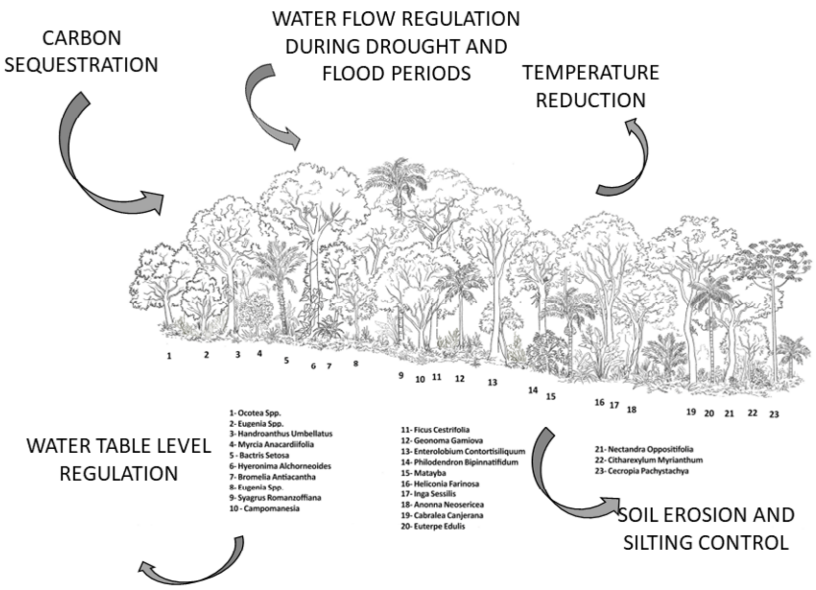
Figure 7 – Ecosystem services provided by sandy forests with emphasis on species for agroforestry systems for *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

Dense rainforest or riverine tropical forest (Figure 8) occurs along the Brazilian Atlantic coast and is characterised by its high precipitation rate, distributed throughout the year, and high temperatures (IBGE, 2012). In the PAN Lagoas do Sul territory, it occurs in the states of Santa Catarina and Rio Grande do Sul, presenting many similarities and some differences in relation to the composition of species. In the state of Santa Catarina, trees, small trees and shrubs represent 34.7% of the plant species found in the formation, followed by epiphytes, which represent 25.2%, in addition to terrestrial, climbing, rupicolous and other species. (Sevegnani *et al*., 2013). The most representative families of epiphytes in the dense rainforest of Santa Catarina are *Orchidaceae*, *Bromeliaceae* and *Polypodiaceae*. In the dense rainforest areas closest to the coast, there are native palm trees such as babassu palm (*Attalea dubia*), *tucum* (*Bactris setosa*), *palmeira-juçara* (*Euterpe edulis*), *guaricana-do-brejo* (*Geonoma schottiana*), *guaricana* (*Geonoma gamiova*), queen palm (*Syagrus romanzoffiana*), *butiá-da-praia* (*Butia catarinensis*) and *buriti* (*Trithrinax brasiliensis*) (Sevegnani *et al*., 2013).

The Floristic Forest Inventory of Santa Catarina characterised dense rainforest based on groupings by altitude ranges, with dense rainforest in lowlands in this state occurring in an altitude range of less than 30 meters, and some of the main species found are *bacupari* (*Garcinia gardneriana*), Cattley guava (*Psidium cattleianum*), *canela-ferrugem* (*Nectandra oppositifolia*), *cupiúva* (*Tapirira guianensis*), *guanandi* (*Calophyllum brasiliense*), *tanheiro* (*Alchornea triplinervia*), *Aniba firmula* and *pau-angelim* (*Andira fraxinifolia*) (Lingner *et al*., 2013), as some of these species also occur in the lowland dense rainforest of Rio Grande do Sul.

In Rio Grande do Sul, the lowland dense rainforest is in contact with the Coastal Plain of the northern coast of Rio Grande do Sul, occurring in sandy-clayey soil of paleodunes or in low-slope clayey terrains, with a hot and humid climate (Brack, 2009). The predominant vegetation formation in this ecosystem is secondary forests found in different successional stages of regeneration, being very similar to the submontane dense rainforest (Brack, 2009). The predominantly arboreal formation stands out, with three to four strata, with trees with elongated trunks, broad leaves and, in some cases, with long tips that function to drain rainwater (Brack, 2009). In addition to the arboreal species, the presence of plants of other life forms is characteristic, such as vines, herbaceous plants, shrubs, epiphytes, hemiepiphytes (Brack, 2009). Epiphytes are very important in dense rainforests, growing on trunks, branches and exposed roots, finding resources and conditions for their survival and reproduction. They interact strongly with fauna, often creating conditions for species of animals, plants and microorganisms to survive (Sevegnani *et al*., 2013).

The emergent stratum, from 20 m to 25 m, is formed by fig trees with tabular roots that shelter a great diversity of epiphytes. In the canopy, in the highest tree stratum, generally dense and continuous, it is possible to find several species, many with use value, such as *canela-ferrugem* (*Nectandra oppositifolia*), *canela-sassafrás* (*Ocotea odorifera*), *cedro-rosa* (*Cedrela fissilis*) and *canjerana* (*Cabralea canjerana*). In the middle tree stratum, some of the species found are *maria-mole* (*Guapira opposita*) and *guamirim-folha-larga* (*Calyptranthes grandifolia*). In the lower tree layer, which reaches a height of up to 10 m, some of the characteristic species are *palmeira-juçara* (*Euterpe edulis*) and *cincho* (*Sorocea bonplandii*). The shrub layer has *guaricana* (*Geonoma gamiova*) and dense patches of native bamboo (*Merostachys* sp., *Guandua* sp. and *Chusquea* sp.) (Brack, 2009). Due to shading, the herbaceous layer is not always well developed (Brack, 2009), and the forest can be managed by pruning to allow light to enter if the development of other plant species characteristic of this layer is desired. On the edges of the lowland dense rainforest, we can find species such as *embaúba* (*Cecropia glaziovii*), *ingá-feijão* (*Inga marginata*) and capulin (*Trema micrantha*) (Brack, 2009).



USE FOR *SOCIOBIOCOTIDIANO*	SPECIES FOR AGROFORESTRY SYSTEMS
FOOD	*Annona cacans* Araticum (a fruit tree native to Atlantic Forest and *Cerrado* vegetation in Brazil and Paraguay) *Campomanesia guaviroba Guabiroba* (South American plant) *Passiflora edulis* Passion fruit *Passiflora elegans* Passion fruit
WOOD MEDICINAL	*Annona neosericea* *Philodendron bipinnatifidum* Split-leaf philodendron
HONEY-PRODUCING	*Campomanesia littoralis Guabiroba* (South American plant)
ORNAMENTAL	*Cattleya intermedia* Orchid *Cattleya purpurata* Orchid *Cattleya tigrina* Orchid *Rumohra adiantiformis* Leather fern
FOOD - WOOD	*Inga marginata Ingá-feijão* (plant found in the Atlantic Forest ecoregion)
FOOD - MEDICINAL	*Inga sessilis Ingá-ferradura* (plant found in Argentina and Brazil)
ARTISANAL - ORNAMENTAL	*Philodendron corcovadense Cipó-imbé* (Brazilian plant)
WOOD - MEDICINAL	*Campomanesia xanthocarpa Guabiroba* (South American plant)
WOOD - ORNAMENTAL	*Nectandra oppositifolia Canela-ferrugem* (South American plant) *Jacaranda puberula Carobinha* (South American plant)
FOOD - ARTISANAL - MEDICINAL	*Euterpe edulis Palmeira-juçara*

Figure 7 – Ecosystem services provided by lowland dense rainforests with emphasis on species for agroforestry systems fo *SocioBioCotidiano*
Source: Based on a drawing by Cláudio Leme.

4 CHARACTERISTICS OF ECOSYSTEMS, WATER, ENERGY, FOOD AND SOCIO-ENVIRONMENTAL SECURITY IN FACING THE CLIMATE EMERGENCY

From the analysis of species with potential for ecological restoration for *SocioBioCotidiano* in the different ecosystems, 53 species and one genus were identified. All ecosystems presented species with potential for restoration for *SocioBioCotidiano*, where wetlands presented the lowest number of species (n=3), in four categories of use, and dense rainforest presented the highest number of species (n=23), in eight categories. The ecosystem services provided by them were identified in ten categories, such as food, aromatic, artisanal, spice, dye, forage, wood, medicinal, honey-producing and ornamental. Food security-related provision services are provided by 14 species. These are found in dry sandy soils (one species), wetlands (one species), swamp forest (one species), sandy forests (three species) and dense rainforest (eight species), in addition to honey-producing species. The wet grassland ecosystem did not present any species with food use.

As for energy security related to the provision of firewood, seven timber species were identified in the literature, with one species found in sandy forests and six species in dense rainforests. However, information on uses related to firewood is not widely available in the literature for these ecosystems. In this context, it can be considered that energy security is provided by the availability of firewood from ecosystems with woody species, such as swamp forests, sandy forests and dense rainforests. Therefore, wetlands, sandy soils and wet grasslands have less potential to provide energy security provided by firewood.

Water security in the territory is related to water body integrity and quality, for which terrestrial ecosystems contribute, both through the riparian vegetation that structures them and through the capacity to retain water on the surface through environments of soils, woods and forests as well as in water tables, through water percolation in the soil throughout all ecosystems. Pereira *et al*. (2024) state that: "... in drought events, a grassland ecosystem richer in plant diversity maintains more stable biomass production than a poorer system, thus having a greater capacity to support wildlife populations even in an extreme event".

Therefore, all the ecosystems analysed provide ecosystem services for regulating water flows and groundwater levels. Soil protection by biomass and the organic layer deposited on the soil surface, together with the root system and the porosity of the soil's bioactive aggregates, promotes infiltration and reduces the speed of water flow, mitigating the impacts of extreme rainfall (Millennium Ecosystem Assessment, 2005). Furthermore, the biodiversity of such ecosystems produces organic matter in a diverse quantity and quality that is above and below ground and contributes to resistance and resilience against various disturbances, such as meteorological fluctuations. These characteristics give grassland and forest ecosystems the ability to buffer the impacts of extreme weather events.

Socio-environmental security is associated with environmental protection provided by native ecosystems, in addition to access to and fair distribution of resources (water, energy and food), which are associated with health and economic development (Coutinho *et al*., 2020). Environmental security, provided by native ecosystems present in rural territories, has a regional influence and functioning, in the case of the metropolitan region, as buffer zones for maintaining temperature, water retention, and supply, among other ecosystem services. The rural-urban connection through supply systems, especially food systems, interconnects rural and urban communities across regions, states, within the country and between continents (FAO, undated). These relationships include short marketing chain promotion, with direct sales on rural properties, at city fairs and in commercial establishments, home deliveries of baskets, and associations in which agriculture is supported by the community and farmers' markets. According to Proctor and Berdegué (2016), diversified marketing options offer potential benefits for both small producers and urban consumers (access, availability and nutrition), including differentiated groups of urban households, such as vulnerable populations, residents of the outskirts, migrant workers and travellers, middle-class consumers, etc.

Among the foods and other products that make up these short marketing circuits in the metropolitan region, there are sociobiodiversity products that, associated with the idea of conscious consumption, consolidate the notion of *SocioBioCotidiano*. According to Francis *et al*. (2005), urban people who are closer to their locally produced food supplies may become more engaged, informed consumers and supporters of multifunctional food production systems and healthy rural landscapes. In the metropolitan region, the Participatory Organic Conformity Assessment Body Rama (Opac-Rama - *Organismo Participativo de Avaliação da Conformidade Orgânica Rama*) (Ramos *et al*., 2013) has a strong presence, connecting farmers from rural areas of Porto Alegre and the metropolitan region with urban consumers. The Safe Housing Program for Agroforestry Systems (Promossaf - *Programa Moradia Segura a Sistemas Agroflorestais*), with the aim of allowing interested families to have new housing with production focused on agroforestry systems, is among the proposals that have emerged to tackle the climate catastrophe, forming a green belt. There is also the Resilient and Sustainable Traditional Territories Program, proposing public policies that guarantee territories and food, nutritional and socio-environmental security of indigenous territories, *quilombolas*, artisanal fishermen and settlements in the metropolitan region and around Laguna dos Patos (Carta das Agroflorestas, 2024). This complementarity between rural and urban territories can provide resilience in the face of climate crisis contexts that tend to be more frequent, which can be strengthened by the ecological restoration of drastically degraded ecosystems in the region.

5 FINAL CONSIDERATIONS

All ecosystems of PAN Lagoas do Sul showed potential for ecological restoration for *SocioBioCotidiano*, with many species occurring in more than one ecosystem, validating the proposition of species arrangement to enrich native plant communities in the countryside, forests and wetlands. Dense rainforest presented the largest number of species and use categories. Wetlands presented the smallest number of species, and wet grasslands, the smallest number of use categories. Provision ecosystem services related to energy and food security, corresponding to firewood and food species supply, are provided by grassland, forest and wetland ecosystems. Terrestrial ecosystems contribute to water security, related to the availability of drinking water, through their interrelationship with surface water bodies, such as lakes, and groundwater bodies, such as water tables.

Native ecosystems provide ecosystem services that also contribute to urban area resilience. Therefore, native ecosystem conservation and ecological restoration are essential to maintain and promote their capacity to capture carbon from the atmosphere and store large quantities in their biomass and soils, in addition to maintaining water quality and food production that supplies urban centres.

As a large part of consumers lives in urban areas, the option for conscious consumption of sociobiodiversity products, which promotes conservation through native ecosystem use and income generation for rural populations, lies in the complementarity between urban and rural areas. These interrelationships that promote security through ecosystem services from native ecosystems unite these territories regionally, strengthening their capacity for resilience and resistance to climate emergencies, whose intensity and frequency tend to increase. Therefore, *SocioBioCotidiano* is a regional supply strategy that promotes biodiversity conservation and restoration, climate change mitigation and socio-environmental justice.

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