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ABSTRACT

Based on reflections related to the Brazilian commitment to the implementation of the Sustainable Development Goals and the challenges involved in reconciling nature conservation, water bodies protection, and sustainable rural production, this article aims to present alternatives to overcome the apparent contradiction between regional development in rural territories and the maintenance of forested areas that produce water. Focused on the North of Rio de Janeiro State, the study applied documentary research and participation in Watershed Committees meetings and in debate forums composed of agroforesters, managers and owners of Private Natural Heritage Reserves (RPPNs) as methodological strategy. It was found that difficulties related to financial sustainability, restrictions on land use in Conservation Units and their surroundings, and in accessing external funding for unconventional agricultural practices act as obstacles to the agroecological transition. It is concluded that it is necessary to intensify institutional mechanisms that promote regenerative development and Sustainability, as well as to regulate existing public policies to foster agroecology at the federal and state levels, strengthening existing networks and creating new agro-sustainable networks that include the participation of Private Natural Heritage Reserves (RPPNs), family farmers, and agroforesters.

Key words: Regenerative development. Permaculture. Agroforestry systems. Conservation Units.

RESUMO

A partir de reflexões relacionadas ao compromisso nacional com a implementação dos Objetivos de Desenvolvimento Sustentável e dos desafios que envolvem conciliar conservação da Natureza, proteção de corpos hídricos e produção rural sustentável, no presente artigo objetiva-se apresentar alternativas para superar a aparente contradição entre desenvolvimento regional em territórios rurais e a manutenção de áreas florestadas produtoras de água. Tendo como estratégia metodológica experiências participativas em Comitês de Bacia Hidrográfica e em fóruns de debates compostos por agroflorestores e por gestores e proprietários de Reservas Particulares do Patrimônio Natural (RPPNs), aliadas à pesquisa documental e foco principal no Norte do estado do Rio de Janeiro, verificou-se que as dificuldades relacionadas à sustentabilidade financeira, às restrições de uso do território em Unidades de Conservação e seus entornos e ao acesso a fomento externo para práticas agrícolas não convencionais funcionam como entraves à transição agroecológica. Conclui-se que é mister intensificar mecanismos institucionais promotores do desenvolvimento e sustentabilidade regenerativos, bem como regulamentar políticas públicas de fomento à agroecologia já existentes a níveis federal e estadual, fortalecendo redes existentes e criando novas redes agrosustentáveis que contem com a participação das RPPNs, agricultores familiares e agroflorestores.

Palavras-chave: Desenvolvimento regenerativo. Permacultura. Sistemas agroflorestais. Unidades de Conservação.

INTRODUCTION

With a total land area of 851,487 million hectares (ha), Brazil has 351,289,816 ha (41.26% of its total area) occupied by agricultural and livestock holdings (IBGE, 2019). 77% of the agricultural and livestock establishments surveyed by the governmental census were classified as family farms, comprising 23% of the total area of Brazilian agricultural and livestock establishments and accounting for 23% of the value of the country´s production (IBGE, 2019). In the Southeast, the total area of agricultural and livestock holdings is 60,302,969 ha, comprising 45.07% pasture, 24.01% forest, 18.99% cropland, and 11.93% other. In the state of Rio de Janeiro (ERJ), the 2.4 million ha distributed across 65,200 agricultural establishments have their land use and occupation comprised by cropland (8.00%), pasture (65.8%), and forest (21.90%). Most of the ERJ's agricultural production is located in the northern region of the state (Machado; Castro; Freitas, 2024), and is based on "agrochemical" monoculture, which is harmful to the environment and human health (Zerpa; Lopéz, 2023), reflecting the need for new forms of production.

In the ERJ, recent studies have shown that there is an inverse relationship between credit for family farming and sustainable regional development, since "*when credit is leveraged, sustainable practices decline*" (Tenchini; Freitas, 2024, p. 17). This reinforces that, in the quest for healthy foods and more sustainable farming methods, the agroecological transition remains a challenge to be overcome at the state level. In a first conceptual approach, agroecology plays two roles: helping to understand the reasons for

the unsustainability of the Green Revolution agriculture and guiding the proper redesign of agroecosystem management from the perspective of sustainability. The theoretical and methodological tools that support this framework are the six dimensions of multidimensional sustainability: ecological, economic, social, cultural, political, and ethical (Caporal; Costabeber, 2004).

Based on the authors' research and field activities, as well as their investigation of agroecological practices and economically viable alternatives related to the establishment of Private Natural Heritage Reserves (RPPNs), this article offers a critical reflection on the evolution of the concept of sustainable development. In light of the conceptual distortion that has occurred as major capitalist interests have taken over the environmental agenda, it is urgent to rethink sustainability in light of the need to regenerate degraded anthropized environments, which are losing ecosystem services that support water and climate regulation. Regarding the advance of neo-extractivist strands of development, on which the state of Rio de Janeiro economy is increasingly dependent, we present the concept of "sinextractivism," related to concrete experiences in agroecology and nature conservation reported herein.

METHODOLOGICAL APPROACH

This paper is the result of the cumulative research and field work carried out by the authors over the past decade, both within the Graduate Program in Environmental Engineering at the Fluminense Federal Institute and through active participation in in-person and remote meetings of the Fluminense Forum of Watershed Committees (FFCBH), the Macaé and Ostras Watershed Committee (CBH Macaé-Ostras), the Lower Paraíba do Sul and Itabapoana Watershed Committee (CBH BPSI), and the State Water Resources Council (CERHI), between 2020 and 2025, as well as at meetings of the Rio de Janeiro State Agroecology Network, Eastern Mountain Region (AARJ-Serrana Leste) between 2023 and 2026, and through interactions in social media groups of the Association of Private Nature Reserves of Rio de Janeiro (APN-RJ). These practical experiences formed the primary empirical basis for the propositions and conclusions developed throughout the study. Additionally, we conducted documentary research on the legal frameworks and on the existence of support mechanisms related to agroecology and organic agriculture at the federal and state levels.

Given that RPPNs have strong potential for the development of agroecological and bioeconomic activities within their surrounding areas, a pilot study of RPPNs management conditions was conducted. This study was based on documentary analysis of available management plans, using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix as evaluation method. In 2025, the ERJ had 196 RPPNs registered with the State Institute of the Environment (INEA), of which 30 had management plan.

The document analysis of the RPPNs' management plans followed a standardized protocol and was subsequently systematized using a SWOT matrix. For each available management plan, information was extracted regarding ecological connectivity, water protection, fire prevention and suppression, management of exotic species, geographic location, public use guidelines, environmental education, research, internal governance, and interaction with public policies. These elements were transposed into technical data sheets, allowing for a horizontal comparison among those Conservation Units (UCs) and subsequent consolidation into a single database. To enhance the reliability of the coding of elements in the SWOT matrix, an external collaborator conducted the classification independently, and after his evaluation the disagreements were solved through analytical consensus.

PAPER STRUCTURE

This paper is structured in three parts: (i) a critical reflexion on the concepts of sustainable development and sustainability, highlighting the need to adopt the concepts of regenerative development and sustainability; (ii) a presentation of public policies and experiences in Rio de Janeiro in the field of agroecology; and (iii) a SWOT analysis regarding the management of RPPNs in the ERJ, focusing on possible convergences between nature conservation and agroecology. These, together with the critique of the formulations of sustainable development and sustainability, underpins the proposal of the concept of sinextractivism presented here.

REGENERATIVE DEVELOPMENT, REGIONAL SUSTAINABILITY, AND NEOEXTRACTIVISM: NEW PERSPECTIVES ON THE ERJ REGION

The concept of development has been subject to renewed debate since the 1980s, driven both by productive restructuring and by discussions surrounding the environmental agenda. This debate, however, has led to crossroads that is not always acknowledged. On the one hand, the old developmentalism, in its various forms, which drove the modernization policies led by the States. Fragmented approaches focused on localism and linked to competitiveness through the attraction of investments from global value chains eclipsed the former formulations,. Based primarily on discussions about "the new industrial spaces" (Scott, 1988), about the "regional engines of the global economy" (Scott, 1996), and the strategies for building local innovation ecosystems (Maillat, 2002), development has come to be aligned to and oriented towards locally or regionally organized actors.

On the other hand, the emergence of the environmental agenda following the 1972 Stockholm Conference raised profound questions about the very foundations of capitalist development, by linking the entropic view to pollution and the extensive and exponential use of natural resources (Georgescu-Roegen, 2012; Meadows et al., 1973). This led to the concept of sustainable development (World Commission on Environment and Development, 1991), in an attempt to reconcile the paradigm of economic growth with social well-being and respect for the planet's limits, representing a true paradigmatic dilemma in development theory. In turn, strategies for competitive development were sought at the local and regional levels, in the pursuit of competitive integration into global flows. However, there was unease regarding the very idea of development itself. The result was the proposal of an agenda to reconcile territorial competitiveness and environmental Sustainability. That agenda culminated, at best, in the maintenance of the discourse of growth as infinite accumulation, with some environmental concessions designed to preserve environmental amenities and address the most explicit aspects of pollution and the destruction of ecological environments.

In the case of the State of Rio de Janeiro (ERJ), in particular, this contradiction has manifested quite intensely. Since the 1980s, the state's economy has been undergoing a process of intense deindustrialization, in which traditional sectors of manufacturing industry have been losing their competitive edge (Silva, 2012). On the other hand, the oil and natural gas extraction industry (O&G)

has taken the place of a dynamic sector of the economy. O&G ensured substantial capital inflows primarily through a range of services related to offshore extraction and production. It provides high wages for skilled workers in various areas of engineering and in specialized technical fields, in addition to respond to vital supplement to municipal and state budgets through oil revenues (Dias, 2025).

Beyond this dilemma—which stems from the very model underpinning modernity—there is also the debate over the future of the regional economy, once production from the pre-salt layer of the Santos Basin begins to decline, a trend expected to occur by the mid-2030s. Most of the options on the table have leaned toward deepening the current model through investments in alternatives stemming from the oil and natural gas extraction industry itself: expanding the natural gas-fired power generation fleet, promoting the industrialization of natural gas (urea and fertilizers), and expanding the service provider network through new port investments, among others.

In this regard, little attention has been paid to alternatives based on the territory's existing potential, beyond the extractive economy of mineral resources. It is in this context that the Atlantic Rain Forest remnants—largely located within RPPNs and other types of conservation units— associated with rural areas allows us to consider an important path for promoting public policies for income generation based on small and medium-sized properties. Given societal commitment to conserve and restore these remnants, we can consider implementing other models of territorial development that guarantee income and food security, alongside environmental conservation and restoration.

The achievement of 2030 Agenda Sustainable Development Goals requires a broader perspective on the promotion of sustainable territory management. Against a backdrop of environmental crisis, climate emergency, and water imbalances and insecurity associated to the current development model, we begin with the following research question: does it still make sense to speak of sustainability and sustainable development? The literature indicates that reversing the degradation or even the overexploitation of commons is vital to achieve SDGs, thus requiring the adoption of measures that go beyond the no longer feasible sustainable development. Mang and Reed assert that the environmental degradation level has reached a point where the capacity of ecosystems to provide life-supporting services, as they have done for millions of years, is seriously compromised (Mang; Reed, 2013).

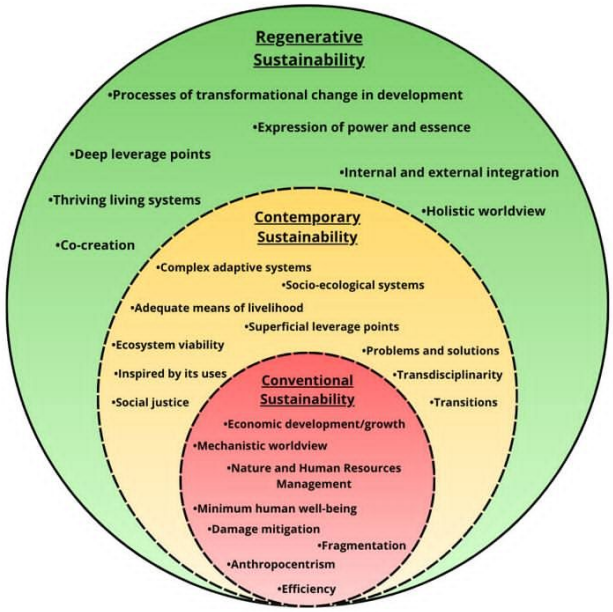
Over the years, sustainability paradigms have evolved: the initial (conventional) conception focused on meeting human needs over time, improving human well-being while simultaneously ensuring the viability of ecological systems. However, a conceptual revision points toward regenerative sustainability (Gibbons, 2020), which is based on a holistic worldview and paradigm, integrating recent insights from science and practice. This new approach includes and transcends the goals of sustainable development, aiming for thriving living systems and being materialized through regenerative development and design (Figure 1). Innovative approaches are important in addressing impacts, so that productive practices, laws, and environmental policies mitigate and adapt to changes resulting from anthropogenic actions in a timely manner. As Krenak (2021) would say:

> *The proposal to slow down our use of natural resources might suggest the idea of postponing the end of the world, but in some places, that end has already come...* (Krenak, 2021).

Götsch (1995) posited that humans must support the natural flow of life, fostering life's inherent capacity to grow, become more complex, and transform entropic waste into living systems, and thus formulated the concept of permaculture, aligned with the concept of syntropy. Coined by the mathematician Luigi Fantappiè, the term syntropy refers to the tendency toward increased organization and complexity, which manifests as an increase in available resources and energy within the ecosystem, given that living organisms behave as open systems that overcome the tendency toward increased entropy by converting environmental resources into growth and production (Ludovico, 2008). Syntropy, permaculture, sustainable agriculture, and agroecology are conceptually related in various ways (Andrade; Pasini; Scarano, 2020). All these approaches stand in contrast to neoextractivist economic practices—the pillars of Latin America's development project—which define its role in the formation of the global capitalist system. Carried out with state-led initiatives, neoextractivism characterize "the mode of insertion and the Latin American role in the formation of the global capitalist system and remain a pillar for its development projects (Fuscaldo; Urquidi, 2015).

Based on the concrete experiences presented here, a new conceptual formulation has born – **sinextractivism** - an alternative development model for the use and appropriation of natural resources, based on permaculture principles and practices that work in harmony with ecosystem dynamics, with a view to fostering the maintenance and provision of an abundance of ecosystem goods and services and promoting regenerative sustainability.

Figure 1 | Schematic representation of the regenerative sustainability model.



Source: adapted from Gibbons (2020).

Given the variety of possible concepts of development presented herein, we have adopted in this essay the most recent critical approach: regenerative development, linking it to rural development and to sinextractivism. We hope, in this way, to contribute to advancing the debate on innovative alternatives for land management in the ERJ, reflecting on challenges and possible paths forward.

PUBLIC POLICIES AND ONGOING AGROECOLOGICAL INITIATIVES: CHALLENGES AND POSSIBLE PATHS TOWARD SINEXTRACTIVISM IN THE ERJ

Approximately 57.7% of the state of Rio de Janeiro's territory is covered by agricultural and livestock areas (including degraded pastures), and 30.1% is covered by forests (Mapbiomas, 2026), including eucalyptus plantations, which have expanded in recent decades (Ferraz & Vicens, 2025). Northern Rio de Janeiro is the region with the largest area of monoculture in the state: data from the ERJ Technical Assistance and Rural Extension Company (EMATER-RIO) identified sugarcane as the state's primary crop, which in 2022 occupied more than 62,000 ha of harvested area (Hissa; Assis, 2025). Sugarcane monoculture is concentrated in ERJ Hydrographic Region IX (CERHI, 2024), which suffers from water scarcity, not only due to the transposition of the Paraíba do Sul River's

waters to the state metropolitan region (RMRJ), but also due to soil degradation caused by sugarcane monoculture and coconut plantations. The northern region of Rio de Janeiro State is home to cities that drive the state's economy through the oil industry and port operations, reinforcing its historically unsustainable neoextractivist orientation. There is a clear lack of support for family farmers and their organizations in councils, committees, and decision-making forums regarding intersectoral public policies that have an interface, interest, and influence on the development of agriculture and livestock on a sustainable basis and the provision of healthy food in food systems that generate employment and income for small local producers.

We argue that, with the support of current agribusiness-oriented development policies, it would be possible to shift the prevailing economic and production paradigm toward regenerative sustainability by transitioning from monoculture practices to agroforestry systems, resulting in tangible gains in both the quality and quantity of production, as well as consequent economic, social, and ecological benefits.

Following the example of federal initiatives, such as the National Policy on Organic Production (Federal Decree 7794/2012) and the National Plan for Agroecology and Organic Production (PLANAPO), now in its third edition, the State of Rio de Janeiro (ERJ) also has a legal instrument that outlines the state policy on sustainable rural development, agroecology, and organic production (PEAPO)—Law No. 8,625/2019. The state law theoretically aims to promote the availability of healthy foods at the state level and establishes a guiding framework for this initiative, known as PLEAPO—the State Plan for Sustainable Rural Development, Agroecology, and Organic Production in Rio de Janeiro. The ERJ initiative aligns with the 2030 Agenda, integrating SDGs 2 (Zero Hunger and Sustainable Agriculture), 3 (Good Health and Well-being), 6 (Sustainable Management of Water Resources), 13 (Climate Action), and 15 (Life on Land), linking agriculture, the sustainable use of natural resources, food, and health. At the foundation of healthy eating lie sustainable production methods, which prioritize the distribution and marketing of these foods, social justice, and environmental integrity.

The agroecological transition outlined by PLEAPO was supported by the Rio Rural Program, which served 2,348 beneficiaries in the northern region of Rio de Janeiro State, including 1,983 family farmers, 135 small-scale producers, and 230 artisanal fishermen. The promotion of

integrated systems (agroforestry and silvopastoral) aimed to enhance the use of trees on rural properties lacking forest cover, contributing to the environmental sustainability of production units. Additionally, the incentive for agroecological and organic production practices advocated for the diversification of cultivated species and the avoidance of pesticides, thereby serving as potential natural pest controllers and providing shelter for native bees, among other agents that generate environmental services. The use of native species aimed to contribute to increasing the resilience of agroecosystems, reducing the likelihood of insect and disease attacks (Oliveira Jr; Cabreira, 2011). In this regard, production units that employ ecologically based management and organic production—preferably operating within socio-technical networks—would become hubs for the redistribution of environmental services essential to production and biodiversity conservation, while also providing a diverse range of healthy foods to the population of the Rio de Janeiro State (ERJ). In PLEAPO, agroforestry systems offer the potential to increase the forestry component in production units, but the primary focus of this state policy prioritizes organic farming rather than agroforestry systems.

The state policy of Rio de Janeiro aligns with that of the Food and Agriculture Organization of the United Nations (FAO) (Zerpa; López, 2023), which proposes in its guidelines the formulation of public policies focused on the circular bioeconomy and the reduction of socioeconomic inequalities, through agroenvironmental conservation and rural territorial development measures. However, it still lacks regulations to allocate the resources provided by the State Environmental Compensation Fund (FECAM) to organic family farmers and agroforestry practitioners, given that overcoming these challenges is essential for sustainable rural production and *"requires incentives to restore the productive capacity of degraded soils and protect water resources, which, in many cases, involves costly practices"* (Hissa; Assis, 2025). Although Article 3 of the National Bioeconomy Strategy calls not only for the promotion of economic and productive activities that foster the sustainable use, conservation, regeneration, and enhancement of biodiversity and ecosystem services, but also for decarbonization (Brazil, 2024), the ERJ runs against COP 30, basing its development on the oil and gas economy, despite. However, Decree 12.044/2024, which, in addition to establishing the National Bioeconomy Development Plan (PNDBio) as its main instrument, set as one of its objectives:

> *"To promote the forestry and sociobiodiversity sectors by identifying, innovating, and enhancing their socioeconomic, environmental, and cultural potential, while increasing market access and income for indigenous peoples, traditional communities, and family farmers."* (Brazil, 2024).

The national framework for "sustainable public policies" has been developed at a slower pace than the need to regenerate our impacted ecosystems, and even without securing resources to incentivize agroecological practices, in 2024 the state government launched the technical and methodological foundations for proposing a protocol to classify the phases of agroecological transition in agroecosystems in the State of Rio de Janeiro (ERJ). It is to be adopted by EMATER-RIO extension agents and by technicians and extension agents involved in related initiatives promoted by SEAS and/or INEA, and/or partner institutions. Called the "IATA Protocol" (Agroecological Transition Assessment Tool), the instrument was developed to diagnose and classify the level of agroecological transition of rural properties in Rio de Janeiro, in order to facilitate access to rural credit, payment for environmental services (PES) programs, and institutional markets.

According to the mapping of initiatives by the Rio de Janeiro Agroecology Network (AARJ), presented in its 2023 online publication, the ERJ has 260 registered agroecological initiatives. This mapping is based on aspects such as sense of belonging, identification, and interaction among networks, institutions, collectives, and social movements within the regions. These eight regions (Costa Verde, Médio Paraíba, Metropolitan, North, Northwest, Serramar, Serrana, and Serrana Leste) reflect not only a geographic division but also cultural, social, and economic diversity (Pena et al., 2023). Agroecological initiatives in rural areas account for 41.5%. The management of these initiatives is family-based, with 192 initiatives led by family farmers and/or peasants. Of the 260 initiatives, 63% do not access public policies, indicating that in practice, government actions to support family farming and promote food and nutritional security are still in their infancy in ERJ. Among the initiatives that do access such policies, 23.4% are for the PNAE, 17.9% through the Organic Agriculture Law, and 17.4% through PRONAF. Reports indicate that the main difficulties faced by family farmers are: the need for infrastructure and inputs, support for marketing, training through courses and the exchange of experiences, as well as operational and logistical structures (Pena et al., 2023). In the discussions held with agroforestry practitioners, we highlight the following statement:

> *"Careful planning and prudent, down-to-earth investment are the cornerstones of avoiding disappointment for farmers. Switching to this technique takes 5, 6, or 8 years to establish a functional agroforestry system; returns are medium- to long-term for fruits and cassava, and short-term for vegetables and beans. Keep in mind that the initial investment is higher for labor and inputs. The more organized the planting, the easier and less expensive maintenance will be."*

Among the various types of agroecosystems described in the literature, agroforestry systems (AFS) are the models that enable the adoption of sustainable management practices, such as intercropping and organic fertilization. The biological diversity of AFSs is fundamental to ecological restoration and, due to the role each species plays within the system (Jackson; Pascual; Hodkgin, 2012), contributes to the economic potential of socio-biodiversity, diversifying opportunities for income generation and employment (Ramos et al., 2009). However, PLANAPO considers AFSs an important alternative only in relation to areas that have already undergone land-use change and are currently in production. In accordance with FAO guidelines, a paradigm shift is necessary. To this end, the government plays a fundamental role in implementing public policies to support AFSs, whose initial implementation costs are high.

For example, the cost of establishing AFSs around the Águas Claras I RPPN (Ferreira; Sardenberg, 2024), located in Conceição de Macabu, was quite high: a medicinal and aromatic AFS covering an area of 70 m² costed R$ 12,000.00 to establish, and a AFS of native and fruit-bearing species covering an area of 0.3 ha (3,000 m²) costed R$ 28,000.00 to establish. The total cost for the 3,070 m² was R$ 40,000.00, a very high sum for a small rural producer, but feasible for the RPPN owner thanks to research project funding from the Carlos Chagas Foundation for Research Support in the State of Rio de Janeiro (FAPERJ). In terms of intercropped species and management, as well as depending on the different harvest seasons, the correct choices for an agroforestry system are critical to recouping the high initial investment, requiring careful planning in the system's design. INEA Resolution 143/2017, which regulates Forest Restoration Projects in the ERJ, can serve as a basis, but it does not detail species intercropping methodologies and establishes a project monitoring routine that, if followed, would result in increased costs; however, it is not mandatory for voluntary restoration initiatives.

NATURE CONSERVATION AND AGROECOLOGY: IS CONVERGENCE POSSIBLE?

According to data from MapBiomas - Collection 10 (MapBiomas, 2024), the expansion of agriculture and livestock farming can be observed across all Brazilian biomes between 1985 and 2025 (Figure 2).

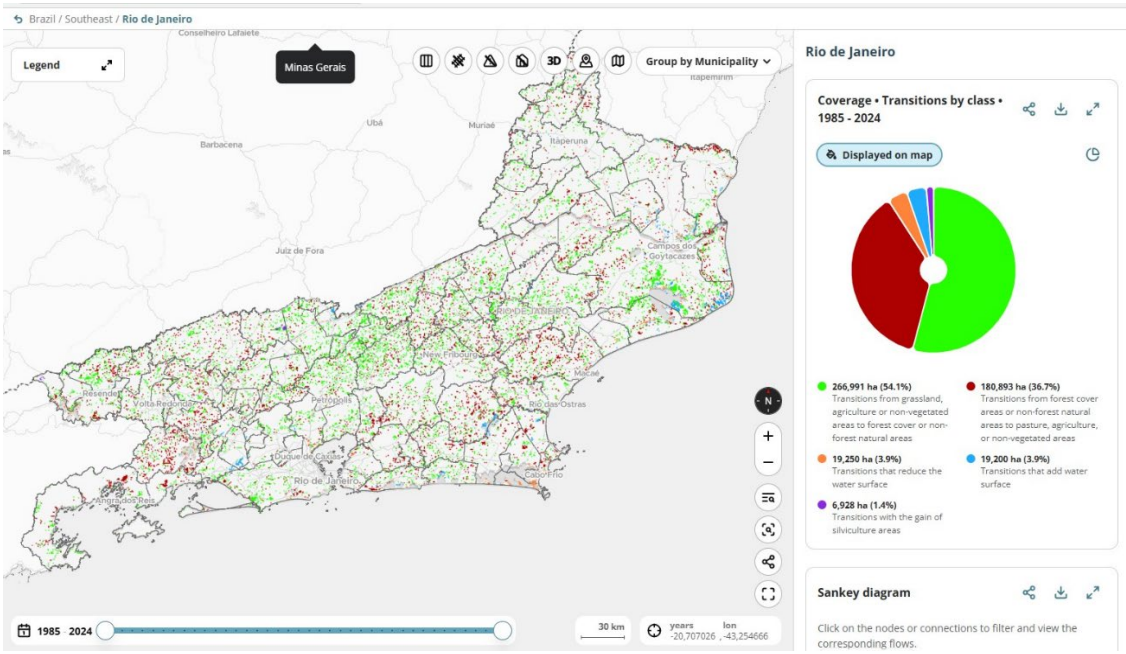


Figure 2. Map of vegetation coverage in the ERJ according to MapBiomasBrasil in 2024.

It is worth noting that the dynamics of land occupation and management in the study area reveal that cooperative forest use practices, characteristic of Indigenous peoples, have been lost at the regional level. In this study, the concept of multidimensional sustainability aligns with that of regenerative sustainability and is understood as the coordinated integration of different axes that, together, determine the viability and longevity of nature conservation actions and of the RPPNs. This is an approach that simultaneously encompasses the ecological, social, economic, spatial, political-institutional, and cultural dimensions, recognizing that none of them, in isolation, ensures effective conservation. On the contrary, it is the overlap and balance between these layers that allow ecological values to be translated into tangible results, strengthen community ties, ensure financial predictability, align governance with the territory, and consolidate the RPPN as a heritage of collective relevance and an effective nature conservation strategy that can work in tandem with agroecology to promote sustainable and regenerative regional development. Through the analysis of the management plans, we created a SWOT matrix highlighting key points and relating them to characteristics observed on agroforestry properties, summarized in Table 1.

Table 1 | Strengths, weaknesses, opportunities, and threats to Private Natural Heritage Reserves in the State of Rio de Janeiro most frequently cited in the analysis of analyzed management plans

	Factor	Common characteristics among the evaluated RPPNs	Observations
Most frequently cited force	**Ecological Connectivity** – Located near or within strategic ecological corridors, promoting the preservation of biodiversity	95,45%	Similarity to agroecological properties
Most commonly cited weakness	**Lack of Infrastructure for Sustainable Tourism** – They lack the necessary infrastructure to accommodate visitors	90,91%	Ideal for agroecological properties looking to develop rural tourism
Most frequently cited opportunity	**Implementation of Interpretive Trails** – Development of educational trails that highlight biodiversity and promote environmental education.	81,82%	Specifically for RPPNs
Most frequently cited threat	**Increased Pollution from Domestic Wastewater** – Unplanned urban growth can compromise the quality of protected water resources	81,82%	Similarity to agroecological properties

A review of the management plans revealed that it is common for landowners to choose to designate only part of their rural property as a reserve, due to restrictions on the direct use of natural resources and, consequently, concerns about the financial sustainability of their assets. The analysis suggests that conservation success depends less on the size of the property alone (whether small, medium, or large) and more on integration into networks (scientific, community, and inter-institutional) that internalize positive externalities (connectivity, applied research, environmental education) and mitigate systemic risks (fires, invasions, land-use pressures).

The SWOT matrix of the RPPNs revealed structural convergence with properties operating AFSs in the ERJ. This comparative analysis was conducted based on the six dimensions of multidimensional sustainability proposed by Fernandes (2004): ecological, economic, social, spatial, political-institutional, and cultural. Thus, we demonstrate that the SWOT analysis of RPPNs serves as a diagnostic mirror for AFSs and that the integration of conservation and agroforestry production constitutes a double-dividend strategy.

In the strengths quadrant, the following stand out: ecological connectivity (mentioned in 95.45% of the management plans analyzed), protection of threatened species (90.91%), and hydrological importance (86.36%), attributes shared by the AFSs. Among the weaknesses, the lack of infrastructure for sustainable tourism (90.91%), dependence on external funding (72.73%), and the absence of strategies to improve financial sustainability (68.18%), deficiencies that are equally common in agroforestry properties (Shennan-Farpón *et al.*, 2022). The mapped opportunities, such as interpretive trails (81.82%) and the valuation of ecosystem services (68.18%), apply to both ecotourism in RPPNs and agroecological rural tourism. Among the threats, contamination by effluents (81.82%) and weak environmental enforcement (77.27%) constitute systemic risks that affect both RPPNs and AFSs indiscriminately.

From an ecological perspective, the convergence is particularly strong: Santos, Crouzeilles, and Sansevero (2019) demonstrated that agroforestry systems in the Atlantic Rain Forest increase biodiversity and act as ecological corridors between forest fragments. The establishment of agroforestry systems around protected areas serves as a buffer strategy that enhances the protection of springs and reduces pressure on the boundaries of private nature reserves. Lima *et al.* (2022) projected a reduction of 38.5% to 56.3% in the bioclimatic habitat area of 135 native species with agroforestry potential, reinforcing that RPPNs and AFSs should act as "complementary refuges."

From an economic perspective, the dependence on external financing (72.73%) and the lack of effective financial sustainability strategies (68.18%) in RPPNs are directly paralleled by the difficulty agroforestry farmers face in covering high implementation costs. Both contexts have multiple, yet underutilized, revenue sources: diversified production, tourism, PES, the Ecological ICMS tax, and carbon credits. The opportunity to raise funds through environmental incentives (63.64%) applies equally to RPPNs and AFSs, requiring predictable, multi-year financial instruments. In the social dimension, the SWOT analysis identifies participatory management (63.64%) and educational relevance (54.55%) as strengths of RPPNs. In AFSs, this dimension manifests itself through knowledge exchange, food sovereignty, and the generation of local jobs. Shennan-Farpón *et al.* (2022) found that agroforestry farmers reported greater food self-sufficiency and plots up to 6°C cooler than uncovered areas. The high percentage of agroforestry practitioners who do not have access to public policies in the state of Rio de Janeiro (63%) shows that both private natural heritage reserve owners and agroforestry practitioners face similar operational isolation.

In the spatial dimension, the SWOT analysis reveals territorial disparities, with RPPNs in mountainous areas exhibiting better connectivity, while units in municipalities facing intense urban pressure suffer from diffuse pollution. The threats of real estate development (63.64%) and highway expansion (77.27%) affect both contexts. Networked projects organized by watershed, linking portfolios between RPPNs and adjacent properties, constitute a spatially appropriate response. In the political-institutional dimension, the SWOT analysis identifies institutional support (68.18%) as a strength and low enforcement (77.27%) as a threat. The regulatory framework in ERJ, including PEAPO (Law No. 8,625/2019) and the IATA Protocol, provides a formal framework for agroecological transition but lacks regulations. At the federal level, Law No. 14,119/2021 (National PES Policy) and Decree No. 12,044/2024 (National Bioeconomy Strategy) expand possibilities. Miccolis *et al.* (2019) noted that the implementation of agroforestry policies remains fragmented, with poor coordination and insufficient resources. In the cultural dimension, although there is no specific category in the SWOT analysis, cross-cutting elements such as scenic landscapes (86.36%) and participatory management convey a sense of belonging and an intergenerational vision. In AFSs, this dimension manifests itself in the appreciation of local knowledge and permaculture ethics. Educational initiatives have transformed the perception of a "closed area" into a "collective learning heritage."

In summary, the SWOT matrix for the RPPNs showed a high degree of alignment with the AFSs' assessment across five of the six dimensions of sustainability, with strong convergence in the ecological, economic, and political-institutional dimensions. The cultural dimension, although present across all areas, lacks explicit systematization. The analysis confirms that multidimensional sustainability constitutes a systemic equation: ecological strength demands institutional and financial chains; the social dimension requires security and participation; the economic dimension is instrumental; the spatial dimension organizes priorities; the political-institutional dimension defines possibilities; and the cultural dimension gives meaning to choices. The integration between RPPNs and AFSs is mutually constitutive: reserves offer ecological refuge and scientific legitimacy, while AFSs expand protection, diversify revenues, and strengthen territorial cohesion. Territorial consortia organized by watershed, with multisectoral governance, agreed-upon goals, and transparency, constitute a promising model of regenerative development that reconciles nature conservation, sustainable rural production, and social justice in the rural territories of the state of Rio de Janeiro, towards synextractivism.

In this sense, RPPN members and agroforestry practitioners exemplify, in practice, the second epistemological break (Khun, 2020) and resilience, just as does the Atlantic Rain Forest they protect, revealing strategies that, if expanded, will contribute to the promotion of regenerative rural development in the ERJ. They continue to resist the impacts of environmental degradation, the need to deal with inadequate management practices in the areas surrounding their territories, the difficulty of accessing mechanisms for the distribution and commercialization of their production, and the costly bureaucratic processes required to formalize their activities. Through self-managed networks, they uphold "ideas to postpone the end of the world" (Krenak, 2019), aligning with alternative planetary visions that "life is not useful" (Krenak, 2020) and that "the future is ancestral" (Krenak, 2022).

FINAL CONSIDERATIONS: PROPOSALS FOR PUBLIC POLICY

Given the loss of connection with sustainable ancestral practices of land use and occupation, farmers in northern ERJ need public policies aimed at implementing agroforestry systems as a source of healthy food and as a way to reconcile rural production with environmental conservation, linked to the solidarity economy. Through ongoing experiences in established agroecological centers, which are willing to transparently discuss the strengths and weaknesses of the economic transition to the agroforestry system, public policies aimed at agroecological transition can be strengthened, with the goal of promoting more socially just and environmentally correct systems.

The body of evidence gathered through the RPPNs' management plans SWOT analysis, and field experiences points to a private conservation landscape of high ecological and social value, which—like the agroecological initiatives in the ERJ—is hampered by financial and operational constraints. Habitat connectivity, water protection, and community engagement are already present in various RPPNs and properties that make up the AARJ, but they lack resource predictability, management routines, and comparable indicators. An analysis through the six dimensions of sustainability shows that lasting results depend on aligning governance, finance, and territory, converting ecological value into auditable, goal-oriented metrics.

In the short term, it is recommended that the government establishes a "common operational minimum," including protocols for fire prevention and response, control of invasive species, signage, and rules for public use that are consistent with sustainable and conservation-oriented practices, as well as routines for monitoring water resources and biodiversity and for enforcing regulations against the illegal subdivision of rural properties. In the medium and long term, it is recommended to consolidate network-based governance arrangements. RPPNs and small properties can formally partner and establish a permanent training schedule and a shared project database; RPPNs and medium-sized properties can seek technical cooperation programs with government agencies and technical and research institutions; RPPNs and large properties can lead landscape management plans, expand targeted restoration of permanent preservation areas and water sources, enter into operational agreements with municipalities and watershed committees, and participate in and/or operate regional training centers.

This highlights the need to shift away from the classic developmentalist paradigm—which views humans and nature as resources that can be overexploited—toward new visions of regional development that go beyond sustainability, regenerating ecosystems and redefining the relationships between economic activities, integrated water management, and nature conservation in the rural areas of the ERJ.

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