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Necessity of Productive Association with Technological Innovations for Sustainability of Extractive Reserves in the Amazon

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Abstract

The first extractive reserves (RESEXs) have completed 32 years of foundation and still encounter environmental and socioeconomic problems. Hence, this study aims to evaluate whether integrating technologies to the productive activities of extractivism, agriculture, and animal husbandry improves the lives of local communities and reduces environmental resource impact. The study employs the association method because more than two variables in the set of environmental, economic, social, and institutional groups manifested a relationship of dependence. Hence, we conclude that the most suitable strategy associates plant extraction, agriculture, and animal husbandry with technological innovations indicated for this model.

Keywords: productive association, technological innovations, environmental conservation, socioeconomic development

1. Introduction

The Amazon is undergoing an intense transition and the emergence of new paradigms on both the use of its resources and its status as an ideal model for environmental and socioeconomic development (Spínola & Carneiro Filho, 2019). Establishing a sustainable economy has never been consolidated, leading to a situation wherein conservation and forest development remain dependent on external resources (Garrett et al., 2021).

Biodiversity conservation and economic revenue can be balanced to responsibly manage ecological and economic compensation in biologically valuable regions (Ball et al., 2020). Local communities in the Amazon depend on logging and non-timber forest resources for food and other basic needs (Evangelista-Vale et al., 2021).

Institutional decisions must be flexible in fulfilling the mission of conservation units (CUs) to guide a new research agenda on conservation and development (Bauch, Sills, & Pattanayk, 2014; Prado, Seixas, & Futemma, 2021). This concern is relevant as the number of CUs has been growing considerably in recent decades, with 10%, 18%, and 70% in the world, Brazil, and the Amazon, respectively (Vieira, Pressey, & Loyola, 2019).

Specifically, extractive reserves (RESEXs) have emerged in response to the problems related to the struggle for land governance and unsustainability resulting from logging, extensive cattle raising, recognition of local communities, and forest conservation (Fernandes-Pinto, 2007; Maciel et al., 2018). RESEXs are located in lowland areas, firm land, and marine ecosystems. Moreover, these are rich in biodiversity and the historical culture of local communities (Gomes et al., 2018).

Hence, initiatives based on local communities have become effective social control tools for the protection of ecosystems, the preventive process of orientation for using the territory, and the possibility of socio-environmental development (Franco et al., 2021). These measures increase the chances of success of public policies for investments in infrastructure, maintenance of natural resources, and economic livelihoods of local communities depending on agroextractive activities (Medeiros et al., 2021; Hoffmann et al., 2021).

However, despite being in operation for 32 years, the oldest RESEXs in the Amazon still face the challenges of sustainably combining the productive activities of extractivism, agriculture, and creation of large and small animals persist (Freitas et al., 2021). Producers encounter difficulties in maintaining productive activities due to low productivity, subsistence conditions, and poor economic performance, owing to a lack of institutional support, incentives, and technical guidance for production (Seabra, 2021).

Additionally, deforestation is growing in almost all RESEXs to develop productive activities, as the seasonal activity of extractivism does not solely guarantee survival. Intensifying deforestation means a setback to achieving the goals set in the National Climate Change Policy (Jesus & Catojo, 2020). CUs are at risk, owing to anthropic increases, weakening of environmental legislation, and inefficient institutional management (Sales et al., 2020).

Furthermore, recognizing the interaction between the economic system and the environment is essential as the economic efficiency advocated by the conventional economy does not always represent social justice and income distribution (Florentino, Silva, & Freitas, 2016). Additionally, financial investment, innovative dynamics, and poverty reduction are needed to secure food security and subsistence in local communities (Cavalcante Filho et al., 2020).

Families cannot survive with low productivity, low profitability of extractive activity conditions, and the difficult logistics of processing and transportation. This makes subsistence insufficient (Barbosa & Moret, 2016). Combining extractivism, agriculture, and large and small animal husbandry with technological innovations is fundamental for the subsistence of inhabitants and the regional economy (Baia, Freitas, & Silva, 2020; Teixeira et al., 2018).

Thus, why are institutions not subsidizing local communities of RESEXs with environmental and socioeconomic projects to utilize primary and secondary forests and reduce deforestation with technologies suitable for extractivism, agriculture, and animal husbandry activities? This study aims to evaluate whether integrating technologies with the productive activities of extractivism, agriculture, and animal husbandry improves the lives of local communities and reduces the environmental resource impact.

The remainder of this paper is organized as follows. Section 2 presents the materials, methods, and their respective subdivisions: research subjects, study delineation, specific procedures, and data analysis. In Section 3, we analyze the data based on the primary collection and approach of the study. In Section 4, we validate and discuss our results in the context of the existing literature. Finally, we present the conclusions and suggestions of this study in Section 5.

2. Material and Methods

2.1 Research Subjects

The RESEXs of Alto Juruá (Marechal Thaumaturgo/Acre), Rio Ouro Preto (Guajará-Mirim and Nova Mamoré/Rondônia), and Rio Cajari (Laranjal do Jari, Mazagão, and Vitória do Jari/Amapá) were studied based on groups of environmental, economic, social, and institutional variables. We considered the criterion covering 32 years of existence, sociocultural potential, biological diversity, and experience between the state and local communities.

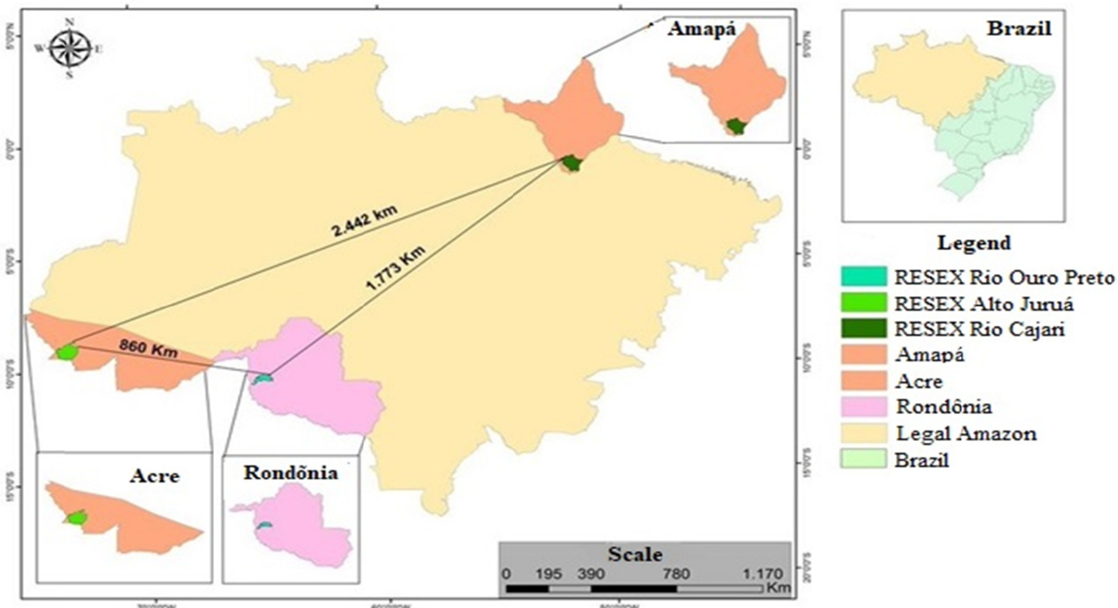

Figure 1. Areas of RESEXs Alto Juruá, Rio Ouro Preto and Rio Cajari and their spatial elements

Source: Authors.

RESEX Alto Juruá was regulated through Decree No. 98.863 with 506,186 hectares (ha) on January 23, 1990. In this area, 4,170 inhabitants live in 80 communities along the main rivers: Ammonia, Breu, Juruá, Manteiga, and Tejo (IBGE, 2010), based on the last demographic census. The economy depends on the production of cassava flour, sugarcane, tobacco, livestock, poultry, and pigs.

Conversely, RESEX Rio Ouro Preto was demarcated by Decree No. 99.166 with 204,583 ha on March 13, 1990. In this area, 699 inhabitants live in 12 communities, banks of vicinal roads, and Rio Ouro Preto (IBGE 2010). Its main economic basis is in Brazilian nuts, cattle breeding, poultry, pigs, and cassava flour production.

Finally, RESEX Rio Cajari was created through Decree 99.145 with 481,650 ha on March 12, 1990. In this area, 31 communities had 2,293 inhabitants residing on the banks of the Cajari River, BR-156, vicinal roads, and creeks (IBGE, 2010). Extracting Brazilian nuts, buffalo farming, bananas, rice, beans, and sweet potatoes are main agroextractive activities.

2.2 Study Delineation, Specific Procedures, and Data Analysis

The study employed the association method as more than two variables in the set of environmental, economic, social, and institutional groups manifested a dependent relationship (Volpato, 2015). For example, in RESEXs, economic policies (labor and income) do not meet subsistence needs specifically, owing to irrelevant credit policies for agroextractivism and low institutional investment in productive activities. Additionally, deforestation, fires, loss of fauna and flora, inefficient conservation, and welfare policies interfere with the socio-environmental and economic sustainability of these areas.

To analyze these groups, this study partnered with managers (heads or environmental analysts) of the Chico Mendes Institute for Biodiversity Conservation (ICMBio) and residents (association leaders and caretakers of family homes) of local communities. This measure provided information on institutional public policies, demographic density, socioeconomic conditions, the environmental situation, and the possibility of adjusting the model to improve the inhabitants' living conditions and conserve natural and environmental resources.

Travel to the RESEXs occurred via air, land, and river transport. Owing to the difficulties of accessing small rivers in the Amazon summer period, this study was conducted at the stations of the floods of the rivers with speedboats (fast river transport). We used 4x4 pickup trucks to access hard-to-reach land communities (vicinal roads).

During the study period, semi-open questionnaires and audio-recorded interviews comprised the primary data collection instruments. The interview roadmap contained questions related to environmental, economic, social, and institutional groups. The survey included heads of the ICMBio offices responsible for each family home, 234 and 150 of which were interviewed from January to March 2017 and 2019, respectively. The study approach was qualitative (through interviews and conversations through forms and audio recorders) and quantitative (through tests of average, median, fashion, and correlation).

3. Results

RESEXs in the Amazon have limitations in the supply of productive activities, difficulties in ensuring financial viability, and market development. Figure 2 shows the socioeconomic reality and subsistence challenges faced by the inhabitants.

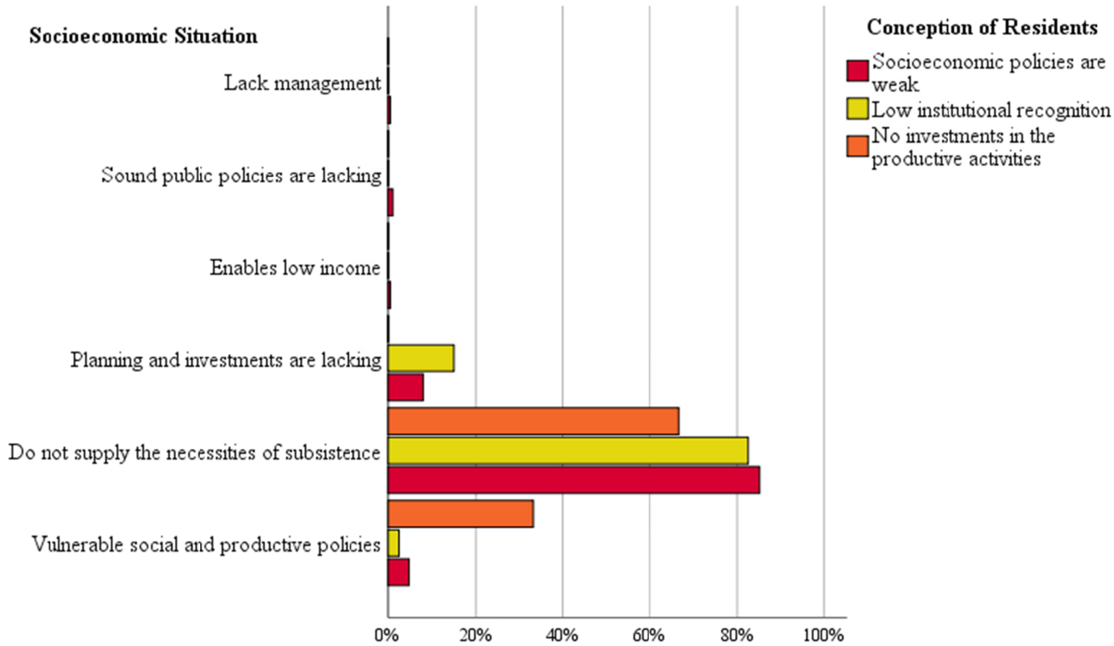

Figure 2. Socioeconomic scenario based on inhabitants' reality

Source: Authors.

Based on interview results, the productive policies of RESEXs are not sufficient and effective for ensuring subsistence needs. This context is relevant as socioeconomic policies are weak, institutional recognition is low, and investments in the productive activities of extractivism, agriculture, and cattle raising are virtually nonexistent in a sustainable manner.

Arguments around environmental sustainability—plant extraction, carbon credits, and payments for environmental services (PSA)—have been considered a new development paradigm by the Brazilian government, ecological movements, international organizations, and foreign governments.

Law No. 14.119, of January 13, 2021, established the National Payment Policy for Environmental Services and Decree No. 10.623 of 02/09/2021, creating the "Program Adopt a Park," establishing the payment of R$ 50.00/ha/year for nationals or € 10/ha/year for foreigners (Freitas et al., 2021). However, implementing and maintaining these policies is difficult and thus creates unrealistic expectations, such as PSA (Figure 3).

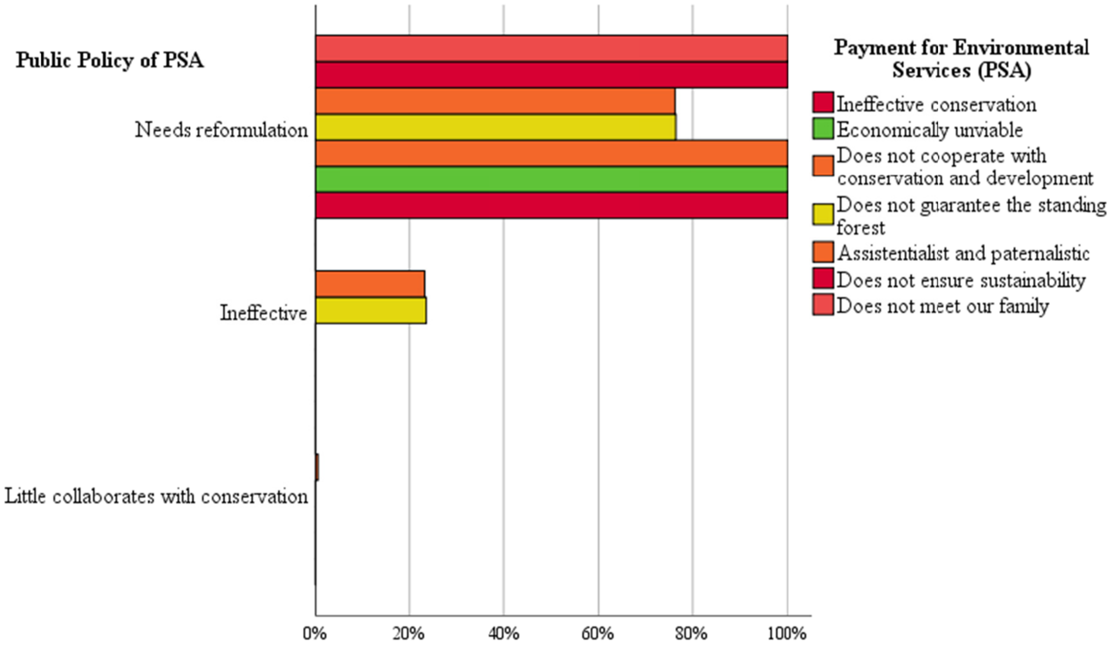

Figure 3. Understanding inhabitants in relation to the public policy of the PSA

Source: Authors.

According to the questionnaire results, the PSA's public policy does not work properly, owing to the small number of residents, low management, and insufficient financial investment. This situation characterizes the PSA policy as assistencialist and paternalistic, owing to economic unfeasibility, inefficiency in conservation and development, non-guarantee of the standing forest, and families' food insecurity (Freitas et al., 2021).

However, investments in productive activities that generate income and utilize secondary areas (altered or degraded) indicate good socioenvironmental practices. Producing cassava flour, corn, rice, sweet potatoes, tobacco, sugarcane, Brazilian nuts, açaí, extraction of vegetable oils, and rearing of animals (e.g., chickens, pigs, and cattle) are some examples of products that can help achieve sustainability in RESEXs (Figure 4).

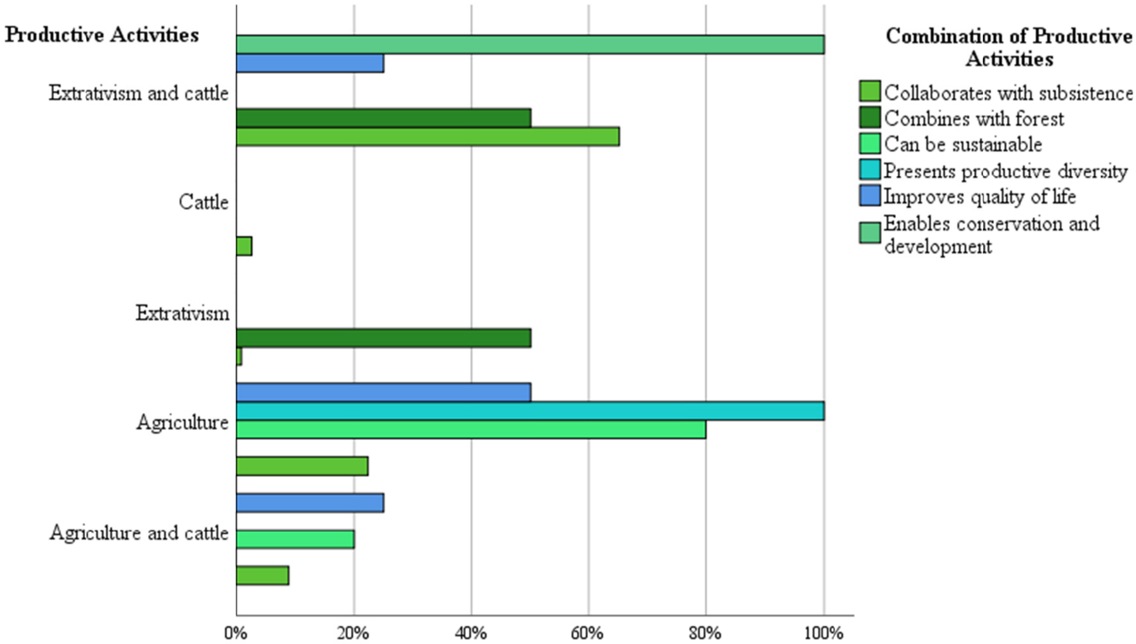

Figure 4. Conception of inhabitants based on the combination of productive activities of extractivism, agriculture, and livestock

Source: Authors.

The questionnaire results showed that investments in the combined productive activities of extractivism, agriculture, and animal husbandry (secondary forests) have low environmental impact and cooperate with increased income. Additionally, the three activities collaborating with family subsistence can be combined with the forest and present productive diversity, thereby enabling conservation with development, improving quality of life and sustainability.

For example, the productive implementation of technologies increases product value, increases household income, reduces the deforestation of primary areas, reduces impact on secondary forests, and qualifies under sustainability parameters. In this sense, projects, if well planned, invested, and managed, can achieve environmental success and provide family subsistence (Figure 5).

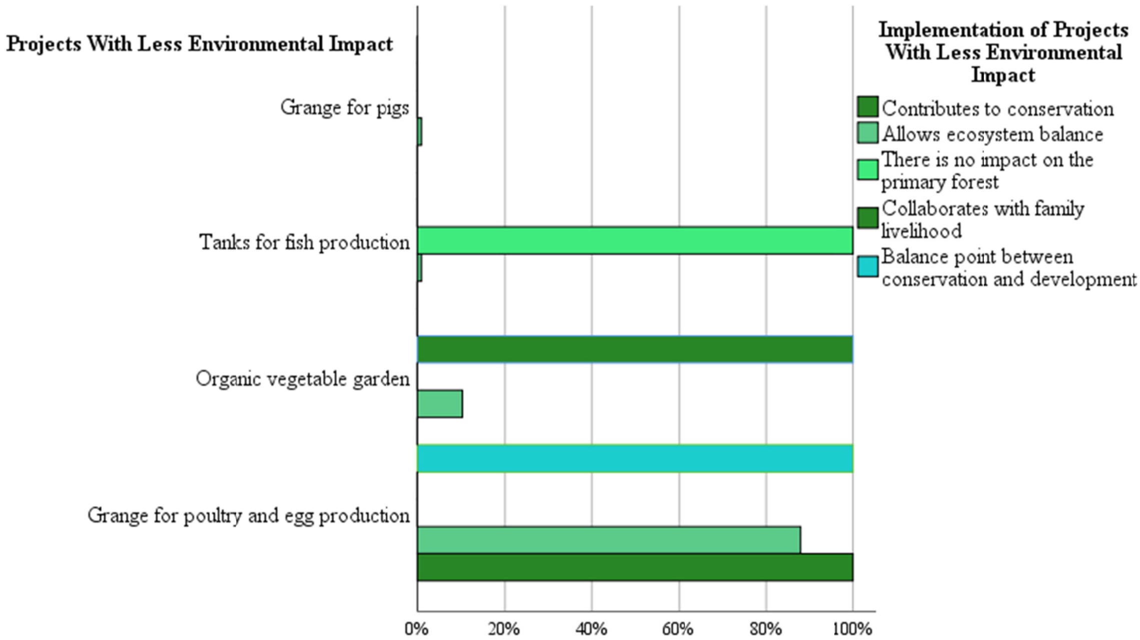

Figure 5. Possibility of implementation of socioeconomic projects with minimal environmental impact

Source: Authors.

As proven by the data, some projects contribute subsistence income and create minimal environmental damage. The alternatives mentioned were the production of birds, eggs, pigs, organic gardens, and fish farms. Residents understand that these projects favor conservation and the ecosystem balance, do not impact primary forests, collaborate with food security, and maintain balance between conservation and development.

These proposals confirm residents' concerns with the annual accumulation of deforestation and the supply of needs indispensable to survival. Despite the reduced relative percentage of deforestation until 2020, due to the size of the RESEX, the deforested area per family has a high value in the Rio Ouro Preto, followed to a lesser extent by the Rio Cajari and Alto Juruá (Table 1).

Table 1. Deforestation in RESEXs Alto Juruá, Rio Ouro Preto, and Rio Cajari

RESEXs/ Creation year	Total Area (ha)	Periods	Deforestation (ha)	%
Alto Juruá (Acre)	537.946	Until 1997	6.539	1,21
1990		2000–2005	4.969	0,92
		2006–2010	3.047	0,57
		2011–2015	1.926	0,36
		2016–2020	3.470	0,64
			19.951	**3,71**
Rio Ouro Preto (Rondônia)	204.631	Until 1997	7.730	3,78
1990		2000–2005	8.966	4,38
		2006–2010	1.695	0,83
		2011–2015	1.231	0,60
		2016–2020	981	0,48
			20.603	**10,07**
Rio Cajari (Amapá)	532.397	Until 1997	7.720	1,45
1990		2000–2005	1.454	0,27
		2006–2010	1.940	0,36
		2011–2015	776	0,14
		2016–2020	869	0,16
			12.757	**2,38**

Source. Adapted from INPE/PRODES, 2022.

The Amazon and RESEXs receive interference from scientists, environmentalists, activists, managers, and tax authorities of national, international, and environmental institutions. These events specifically occur due to deforestation and loss of fauna, flora, and/or environmental resources. However, no effective methods have yet been presented that integrate forest conservation with the improvement of the local inhabitants' living conditions.

Exclusive preference for natural resources is not sufficient to ensure that the forest is intact or standing, as deforestation continues in the three oldest RESEXs in the Amazon, created in 1990. RESEX Rio Ouro Preto was the smallest in population and territory; however, this has experienced greater deforestation than the others, especially until 2005. Cattle are the predominant productive activity in nearby roads—Bom Sossego, Cachoeirinha, and Pompeu—causing the greatest environmental damage. Owing to questions of conflicts of interest, Bill No. 10.493-C of 2018 (Federal Senate) is in progress, which authorizes in in the wake of common agreement the dismemberment of 20,462 hectares of RESEX Rio Ouro Preto.

Thus, RESEXs Alto Juruá and Rio Cajari have similar territorial dimensions; however, their populations are disproportionate. The former includes a greater number of inhabitants, cattle culture, and agriculture, which justifies the rate of deforestation in the periods studied. The second, in addition to cattle, has production and investment in Brazilian nuts, which explains its lower rate of deforestation compared to Alto Juruá and Rio Ouro Preto. Highlighting that the three RESEXs reared cattle herds and buffaloes is important, and the founding strategy did not allow for expansion of this productive activity.

4. Discussion

Associating plant extraction with agriculture, large and small animal husbandry (in a sustainable way), and its technologies contribute to environmental and socioeconomic sustainability of local inhabitants and have a low impact on natural and environmental resources. However, public policies for income transfers (e.g., PSA and productive activities, such as extractivism, agriculture, and cattle), in isolation, have not guaranteed the subsistence of local populations.

This situation demonstrates that public policies for income transfers do not outweigh the families' needs and cannot collaborate with development and conservation (Araújo et al., 2017). For example, payment programs for environmental services (PSA) and carbon credits (CC) provide environmental services and defend carbon stocks' potential but ignore the traditions, culture, and livelihood of forest dwellers (Pereira, 2010; Yanai et al., 2016).

Instead of creating diffused or artificial markets (sale of carbon credits or environmental services), creating technological and economic alternatives would lead to greater production of food and raw materials with less environmental damage to various rural regions of the Amazon (Homma, 2020). The PSA experience in RESEXs was not successful as the Bolsa Verde Program benefited some families with 300.00 BRL (every three months), but this ended in 2018. We complement the fact that retirements, Bolsa Família, and Seguro Defeso (government transfers) are significant in the sustainability strategy of several families.

Another factor hindering socioeconomic sustainability is the worsening of rural communities' food conditions owing to the lack of commitment and awareness of public institutions (Silva et al., 2020). These conclusions confirm the field evidence, and we add that the conducted projects have a high priority for ecosystem resources and low preference for quality of life.

Socioeconomic vulnerability and social inequality have increased considerably in these areas (Oliveira, Andrade, & Souza, 2020; Rocha et al., 2020; Jaeggi et al., 2021). Moreover, the effectiveness of programs and projects (Thuy et al., 2020) have not been empirically proven, given that the implemented public policies do not correspond to local communities' socioeconomic needs (Alves-Pinto et al., 2018; Silva, Meneghetti, & Pinheiro, 2020). These fundamentals were verified in our data collection as the state did not demonstrate medium- and long-term projects with viability to improve inhabitants' living conditions.

To alleviate the social gap, productive practices should be guaranteed, public policies promoted and reformulated (Vela et al., 2020), or impact on per capita income reduced (Pham et al., 2021). These actions would reduce inequality, exclusion, participation, access to funds, and credits (Haas, Loft, & Pham, 2019) and would not disregard the added value to the environment and opportunity cost of community participation (Ram, 2019). These failures in planning, management, control, and effectiveness make the achievement of social well-being and reduction of the annual rate of deforestation of the RESEXs difficult.

Furthermore, the integrated production of both timber and non-timber products are alternatives that can allow sustainable flow (Klimas et al., 2012), provided that these respect local culture, interact with nature, integrate socioeconomic and ecological factors (Gaoque et al., 2016), and cooperate with the construction of regional markets (Sangalli et al., 2021). These elements are idealized by local communities; however, they lack the ability, knowledge, and institutional understanding to ensure truly sustainable RESEXs.

For example, integrated or combined production of extractivism, agriculture, and livestock can be instrumental in conserving the rural landscape, income, and food security (Bulege, 2011; Dick et al., 2021; Fraxe et al., 2018), under the condition of including social actors to new forms of leadership (Granada, 2015; Cortés, 2015) and addressing social and environmental issues (Ruiz-Pérez et al., 2005; Carmenta, Coudel, & Steward, 2019). We confirm that, excluding the management of açai palm trees, income provided by extractive activity is very low. However, by combining products of agricultural origin and animal husbandry, the increase in income is significant.

In this sense, the diversified production of agroextractivism increases product supply, local potential, knowledge, and farmers' decision-making (Erazo, Silva, & Costa, 2020). Additionally, combinations involving annual crops, perennials, livestock, extractivism, fishing, reforestation, location (upland and lowland), and nonagricultural activities are strategies for strengthening agroextractive activities (Homma, 2021). Livestock can improve production, benefit farmers and environmental impacts; however, care for the combination of pastures with silages needs to be redoubled (Nepstad et al., 2019).

Most inhabitants of RESEXs perform chestnut extraction, vegetable oils, hunting, and fishing. Cassava flour, rice, beans, corn, sweet potatoes, brown sugar, and tobacco are primary agricultural products. Additionally, poultry, pigs, cattle, and buffalo rearing are key in the livestock aspect. We have proven that most producers do not usually associate or combine three productive activities for commercialization, usually specializing in an activity owing to lack of financial resources, opportunity cost of time, affinity, and expressive acceptance in the market.

To reduce these deficits, both the Amazon and sustainable-use CUs need to increase their agricultural productivity to reduce pressure on natural resources and promote domestication of potential plants, replace imports (internal and external) of tropical products (rubber, palm oil, cocoa, rice, milk, poultry, eggs, vegetables, etc.), and provide incentives for recovery of areas that should not have been deforested (Homma, 2020, p. 32). We demonstrate that the combination and productive diversification meet food needs with less environmental damage.

If these possibilities do not enter the agenda of implementation and/or planning and investments, deforestation rates will continue to threaten fauna and flora (Ford et al., 2020; Kröger, 2019). The behavior of local inhabitants proves that the forest will not be intact as socioeconomic needs are indispensable for survival.

In this context, CUs are not effective for the protection of biodiversity and environmental services (2004 to 2017) as deforestation reached 11.4% in indigenous lands, 16.9% in full protection CUs, 10.4% in RESEXs, Sustainable Development Reserves and Public Forest, and 35.8% in the Environmental Protection Area, Area of Relevant Ecological Interest and Natural Heritage Reserve (Pereira & Ferreira, 2021).

RESEX Chico Mendes is an example of an environmental crisis as it accumulated in one year (2019) of deforestation of 7,900 hectares, the largest in history (INPE, 2022). The Amazon's RESEXs face difficulties in containing advances in deforestation. We found that including technological innovations can increase production, add value to agroextractive products, and reduce impacts of primary and secondary forests.

RESEXs face difficulties in implementing financial and human resources owing to the low priority of actions necessary for economic and socio-environmental development (Souza, Richter, & Costa, 2019). Although rules are important elements of governance in CUs, any study focusing exclusively on rules can cause limitations that affect inhabitant behavior (Ostrom, 2005; Capelari et al., 2020). RESEX heads were instructed to protect and present projects for biodiversity purposes. We understand that the state should come into consensus and include investments in productive activities to ensure consistency between conservation and development.

The Boserupian crisis, such as population growth and low productivity maintenance, is present in RESEXs. As population density increases, soil fertility can no longer be preserved by long allow, which makes the introduction of other systems requiring a much larger agricultural workforce necessary (Boserup, 1987). This context causes the modernization of mechanized equipment, introduction of chemical fertilizers, reduction of production per man-hour, increased food production, valorization of rural skills, and communication at primitive producer levels (Boserup, 1987, p. 141).

Generally, local communities wait for possible partnerships, projects, and institutional programs, of which they are committed to minimal environmental wear and livelihoods. Plant extraction in primary forests, productive activities in secondary forests, and an increase in technological innovations are strategies capable of significantly transforming the reality of RESEXs.

5. Conclusions

Conducting deforestation and burning to ensure survival in RESEXs for the planting of annual and perennial crops or developing livestock for food production and selling the surplus for the acquisition of extra-property products is necessary. Felling of forests for the establishment of “mowing” and/or pastures is common in RESEXs. Practically, we noticed institutional disinterest in socioeconomic projects and preference for extractive or similar projects that defend the fauna and flora in the forests of RESEXs.

Absence of technological supply and economic and environmental alternatives complicates the improvement of living conditions of inhabitants and the reduction of their impact on natural resources. However, payments for environmental services, carbon credits, and preferences for fauna and flora do not coordinate to achieve sustainability. The proactivity of inhabitants of the RESEXs is important for improving income, developing more sustainable activities, and reducing dependence on direct government transfers.

Here, we conclude that the most suitable strategy is the combination of plant extraction, agriculture, and breeding of large and small animals (adequately) with technological innovations indicated for this model. Integration and diversification increase the socioeconomic conditions of local inhabitants and reduce impacts on natural and environmental resources, if well conducted.

From this perspective, strengthening extractivism (Brazilian nut, extraction of vegetable oils, hunting, and fishing), agriculture (cassava flour, rice, beans, corn, sweet potatoes, brown sugar, and tobacco), and breeding of animals (poultry, pigs, cattle, and buffaloes) will be possible with credit opening, sensitivity of institutional managers, and public-private partnerships. Institutional projects and programs should allow conditions favoring the livelihoods of local inhabitants, as environmental sustainability depends on socioeconomic factors.

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