

Historical trajectory and resilience in an agro-extractive settlement project in the Lower Tocantins River, Pará, Brazil

Trajatória histórica e resiliência em um projeto de assentamento agroextrativista no Baixo Rio Tocantins, Pará, Brasil

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ABSTRACT

The São João Batista riverside community experienced a golden phase in the production of cachaça from sugar cane (*Saccharum officinarum* L.). It underwent a period of decay around 1975 and, in 2004, became an Agro-extractive Settlement Project (PAE), with an economic system based on the exploitation and commercialization of açaí (*Euterpe oleracea* Mart.). This study analyzes the resilience of PAE São João Batista, Abaetetuba, Pará, from the establishment of sugar cane mills to the transition of their economic system to the exploitation and commercialization of açaí. It was based on field research conducted with 141 riverside dwellers employing semi-structured interviews. The adaptive cycle was built up, from which resilience was analyzed. The growth of the açaí fruit market identifies the community's point of resilience. The sugar cane-açaí economic system transition enabled riparian populations to experience changes and to create conditions for reorganizing themselves as a settlement.

Keywords: Adaptation. Uses of biodiversity. Socioecological System. Abaetetuba.

RESUMO

A comunidade ribeirinha São João Batista vivenciou uma fase áurea da produção da cachaça de cana-de-açúcar (*Saccharum officinarum* L.). Tendo passado por um período de decadência por volta de 1975, veio a se tornar um Projeto de Assentamento Agroextrativista (PAE) em 2004, agora com seu sistema econômico baseado na exploração e comercialização do açaí (*Euterpe oleracea* Mart.). Este estudo analisa a resiliência da comunidade do PAE São João Batista, Abaetetuba, Pará, em função do estabelecimento de engenhos de cana-de-açúcar e a transição do sistema econômico para a exploração e comercialização do açaí. O estudo se baseou em pesquisa de campo com 141 ribeirinhos por meio de entrevistas semiestruturadas. Construiu-se o ciclo adaptativo, a partir do qual foi feita a

análise de resiliência. O crescimento do mercado do fruto de açaí assinalou o ponto de resiliência da comunidade. A transição cana-açaí efetivou a capacidade dos ribeirinhos de experimentar mudanças e criar condições para se reorganizarem enquanto assentamento.

Palavras-chave: Adaptação. Usos da biodiversidade. Sistema Socioecológico. Abaetetuba.

1 INTRODUCTION

Amazonian socioecological landscapes were shaped by human action in different intensities, and the use and exploitation of their natural resources have led to a stage of conflicts and struggle involving various actors and interests (ATHAYDE *et al.*, 2016). Among these actors are the traditional populations who socially reproduce their ways of life by interacting with the environment.

In the floodplains of the Amazon estuary, *ribeirinhos*¹, or riparian communities, have established systems of utilizing natural resources that combine various subsistence activities based on family labour and use of low-impact technologies derived from traditional knowledge (FERREIRA, 2012; LIMA; POZZOBON, 2005). Concerns about recognition of territorial rights of traditional populations and sustainability of territories and production systems induce the creation of rural territories of agro-extractive identity, which culminated with the advent of Agro-extractive Settlement Projects (Brazilian acronym: PAEs) as units of conservation of sustainable use, fulfilling the demands of the environmental movement and the land claims of social movements (ARAÚJO *et al.*, 2019).

To understand how communities are affected by and respond to disturbances, complex systems theory has been applied through the representation of socioecological systems (Brazilian acronym: SSE). In the Tocantins River, in the large area affected by the Tucuruí dam, Bentes *et al.* (2014) showed that some communities have been organizing themselves through fishing agreements, towards better living conditions. This indicates that the changes directly or indirectly associated with habitat destruction, climate changes and overexploitation of biodiversity (SILVA *et al.*, 2020) have been hitting human groups that greatly depend on natural resources through their effects on socioecological systems (HE; SILLIMAN, 2019).

PAEs may be regarded as a model of socioecological system where the social system includes farmers, extractors and fishermen, and their respective modes of production, institutions, production chains, social processes and relationships. The ecological system is addressed in different scales, ranging from the several terrestrial and aquatic environments to the unit of species extracted from these settlements. The social and ecological systems interact with each other, resulting in an “agro-extractive system” within socioecological systems on a wide scale, such as the international market (of açaí, for instance), biomes, global climate, etc. (OSTROM, 2009).

Under such a perspective, there is the resilience approach, whose society-nature interface is regarded from the feedback relationships that characterize the SSE (LINDOSO, 2017). The resilience of a system is defined as the ability of that system in dealing with disturbances while maintaining its functions (FOLKER *et al.*, 2004). In the Amazonian context, Buschbacher (2014) uses the word resilience as meaning “the ability to deal with uncertainties, changes and surprises through adaptation, learning and self-organization”. Through the adaptive cycle (HOLLING; GUNDERSON, 2002), one can describe how change patterns and processes over time occur in systems.

In that context, a historical review of the access to land and the survival strategies of riparian communities concerning the effects of environmental events and their consequences as well as their ways to adapt to the capitalist market allow for an analysis of their socioecological resilience and the possibilities of long-term planning. Particularly for the traditional Amazonian populations, the ability of socioenvironmental systems to respond and adjust to their milieu demonstrate their role in the conservation of the Amazonian Forest vis-à-vis global environmental changes, for their power of mediation of political transformations in various scales and territories (FLEURY *et al.*, 2019).

This paper analyzes the trajectory and resilience of PAE São João Batista, in the municipality of Abaetetuba (State of Pará), based on some elements of socioecological systems and resilience approaches (HOLLING, 2001; WALKER *et al.*, 2006). By considering the adaptive cycle as a heuristic model, this approach has been employed to explore the dynamics and change trajectories of SSEs since the establishment of sugar cane mills in 1930 and the transition of the economic system to the exploitation and commerce of açaí. Resilience trends were analyzed in the light of the dimensions of social, economic and environmental capitals (SALVIA; QUARANTA, 2015), taking into account the different phases of the adaptive cycle.

2 MATERIAL & METHODS

2.1 STUDY AREA

The Municipality of Abaetetuba (01°43'24" S, 48°52'54" W) has a population of 141,100 inhabitants (IBGE, 2010) and its economy is mainly based on fishing, extractive gathering – foremost, of açaí) and agriculture (BARROS, 2009). Together with ten other municipalities, it constitutes the Lower Tocantins region, and its history is associated with the process of colonization of Amazonia, which is characterized by a model of economic integration with international capitalism (MACHADO, 2008).

From a socioenvironmental standpoint, Abaetetuba presents an expressive diversity punctuated with knowledge, memories, activities, symbologies, customs and a routine intertwined with the spaces of rivers, forests and floodplains (POJO; ELIAS, 2018). The municipality includes 72 islands that are geographically located in the lower course of the Tocantins River, at its confluence with the Pará River, in the estuary. The region is predominantly formed by floodplains and inhabited by riparian communities and *quilombolas* who are more or less intensely linked with the city, depending on their respective distance from urban centres (BARROS; SILVA, 2013).

For this study, we chose the island of Campompema (Figure 1), Pará, where the PAE São João Batista is located. The selection of this area is justified because it is one of the first localities where an Agro-extractive Settlement Project (PAE) was implemented in the Amazon, as part of the set of land recognition project models created in 2004 as a way to boost economic and environmental actions in floodplain areas historically occupied by traditional populations.

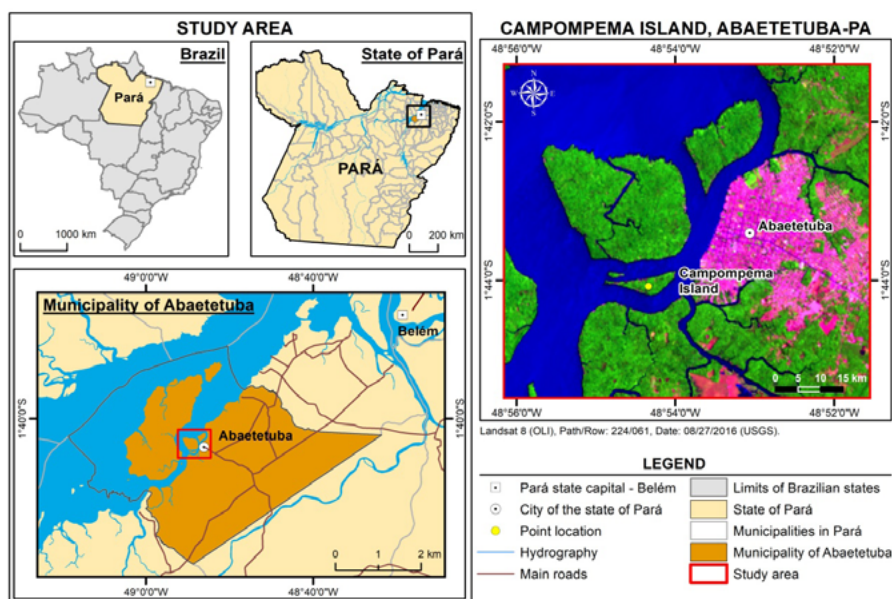


Figure 1 | Study area.

Source: Elaborated by the authors.

PAE São João Batista was created through Ordinance Incra/SR (01)/Nº 27 of 27 July 2004, published in the *Diário Oficial da União* [Official Gazette of the Union] Nº 146 of 30 July 2004, Section I, comprising an area of 471,961ha (INCRA, 2017). This settlement is the result of the struggles of local social movements to achieve land regularization. Initially, the riverside dwellers received the Sustainable Use Authorization Term issued by the Union Heritage Secretariat, this document being a facilitating element for access to government social benefits and effective for proving residence (IPEA, 2015). The riverside population of PAE São João Batista have developed survival strategies based on the use of natural resources, both related to fishing and extraction of forest products, to adapt to the political, social, environmental and economic changes. The São João Batista settlement experienced the golden phase of sugar cane cachaça (*Saccharum officinarum* L.) production in the 1960s; it had its moment of decay 15 years later, and in 2019, as a rural settlement, it starts to enjoy an economic system based mainly on the exploitation and commercialization of the açai fruit (*Euterpe oleracea* Mart.), which has a global market.

2.2 DATA COLLECTING

To conduct this analytical-descriptive research meetings were initially held with the community leadership for exposure of the nature of the work and authorization of the research through the Written Informed Consent Form (WICF). Subsequently, the documents resulting from this previous moment were forwarded to Plataforma Brasil for evaluation. The Research Ethics Committee of the Health Sciences Institute of the Federal University of Pará (UFPA) approved its execution under CAAE 74844417.4.0000.0018.

The study included field research conducted from March to August 2018 in PAE São João Batista. The subjects involved in the research were the residents of the settlement area, totalling 141 interviewees (49% of the population residing in the PAE). The age of the interviewees ranged from 18 to 59 years, with a higher percentage (67%) of women.

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Semi-structured interviews aimed at probing the population's way of life and identifying historical events and main factors influencing the trajectory of the establishment of the settlement. The interviews were carried out from 7 AM to 5 PM at the interviewees' residences, with a maximum of three interviews per day. As land ownership and access to natural resources in the São João Batista community are subjected to the rules of the Agro-extractive Settlement Project, the interviewers were aware that some questions could cause some discomfort due to concerns of financial or material loss. Therefore, interviewees were allowed to interrupt the questioning at any time, ensuring their autonomy and free will.

The interviewees' reports are referenced throughout the text with the initial letters of their name and age, guaranteeing the confidentiality of their identity. Subsequently, research was carried out in scientific literature (articles, books and institutional sites) to verify the political interventions in the settlement, in addition to historical records.

2.3 ADAPTIVE CYCLE CONSTRUCTION

Holling (2001) proposes a four-phase adaptive cycle model, where a system grows slowly (exploration phase), accumulates wealth for a sustained period (conservation phase), collapses (release phase), and rapidly reorganizes (reorganization phase), allowing it to grow in an identical or different configuration (HOLLING; GUNDERSON, 2002).

The identification of the four phases of the adaptive cycle: *r* – exploitation; *k* – conservation; Ω – release and α – reorganization was carried out based on the interviews and literature consultation, going through the adaptive cycles of sugar cane and in that of açai, from 1930 to 2018. Thus, it would be possible to cover the reconstruction of the historical memory of local actors, even because this period marked the transition from sugarcane agriculture to the management of one of the most important species of Amazonian extractivism, which participates in the global market.

To describe the phases of the adaptive cycle, the assumptions detailed in Table 1 were considered, with the attribution of values referring to social, economic, and natural capitals, with 1 (one) for the criteria considered strong and 0 (zero) for those considered weak, according to Salvia and Quaranta (2015). Strong capital ensures a high level of resilience potential, as well as, conversely, weak capital signals an inability of the SSE to adapt, transform and respond overall to change, thus influencing the degree of resilience of the system. The criteria were identified by combining the components that would indicate whether the economic, social and natural capital would be well or poorly developed in the settlement.

Table 1 | Criteria for assessing resilience in the various phases of the adaptive cycle in the cultivation of sugar cane and açai in PAE São João Batista, Abaetetuba, Pará.

Phases (years)	Capital			Description
	Social	Economic	Natural	
Exploitation (r) 1930 - 1950	Presence of united community, high diversity (1)	Riparian populations with a wealth of resources; high commercialization (1)	Planting without threatening local biodiversity; species such as açai managed for survival (1)	Strongly developed socioeconomic and environmental capital (1)
	Absence of united community, low diversity (0)	Riparian populations without a wealth of resources, highly dependent on outside financing; low commercialization (0)	Monoculture; landscape simplification; soil degradation (0)	Poorly developed socioeconomic and environmental capital (0)
Conservation (k) 1960 - 1973	Good communication between social actors; investment in infrastructure and institutions for the education of children and youngsters (1)	High productivity; production flow; generation of employment and income for families (1)	Low degradation of forest and soil; preservation of water resources (1)	Strongly developed socioeconomic and environmental capital (1)
	Lack of communication between social actors; lack of investment in infrastructure and institutions for the education of children or youngsters (0)	Low commercialization of resources; difficulties in the production flow and the generation of employment and income (0)	High degradation of forest and soil; water resources depleted (0)	Poorly developed socioeconomic and environmental capital (0)

Phases (years)	Capital			Description
	Social	Economic	Natural	
Release (Ω) 1975 - 1987	High diversity; incorporation of traditional techniques of cultivation; support for community social programs (1)	High product commercialization (1)	Low exploitation of açai (1)	Strongly developed socioeconomic and environmental capital (1)
	Low diversity; technological precariousness; lack of support for community social programs; precarious employment situation; job informality (0)	Low product commercialization (0)	Sharply increased process of açai exploitation (0)	Poorly developed socioeconomic and environmental capital (0)
Re-organization (α) 1990 - 2004	The ability of the organization in networks and key institutions such as co-operatives, associations; the presence of consulting services for riparian communities (1)	The low requirement to import resources for community survival; the extractive gathering of plants as a source of income and job assurance (1)	Natural resources available for exploitation: good water and soil quality (1)	Strongly developed socioeconomic and environmental capital (1)
	The inability of organization in networks and key institutions such as co-operatives, associations; absence of consulting services for riparian communities (0)	The high requirement to import resources for community survival (0)	Natural resources unavailable for exploitation: poor water and soil quality (0)	Poorly developed socioeconomic and environmental capital (0)
Exploitation (r) 2007 - Current	Social mobilization: the presence of schools and services for riparian communities; social integration of families (1)	High resource commercialization; participation in programs of financial support; acceptance in markets (1)	Good soil and water quality; preservation of local biodiversity (1)	Strongly developed socioeconomic and environmental capital (1)
	Absence of social organization; lack of schools and services for riparian communities (0)	Low resource commercialization; lack of participation in programs of financial support; rejection in markets (0)	Monoculture; soil degradation; poor water quality; local biodiversity threatened (0)	Poorly developed socioeconomic and environmental capital (0)

Source: Elaborated by the authors.

Changes in the PAE were analyzed in light of the dynamics that shaped the social, economic, and natural capitals described in Table 1. The analysis of resilience trends, extrapolated from the trajectories of the three different types of capitals, led to the construction of the adaptive cycle from 1930 to 2018 for the sugar cane cultivation and açai production sectors. Based on the criteria presented in Table 1 and, subsequently, based on the levels attributed to the capital (strong or weak), we obtained the valuation and indication of resilience in each phase of the adaptive cycle as Not Resilient = 0; Slightly Resilient = 1-2 and Resilient = 3. The resilience indicators incorporate the different phases of the adaptive cycle and can act as a barometer of overall resilience, because their presence suggests a resilient SSE, while their absence or disappearance suggests a loss of resilience and greater vulnerability to disturbances (CABELL; OELOFSE, 2012). The flowchart of the research with its steps is presented in Figure 2.

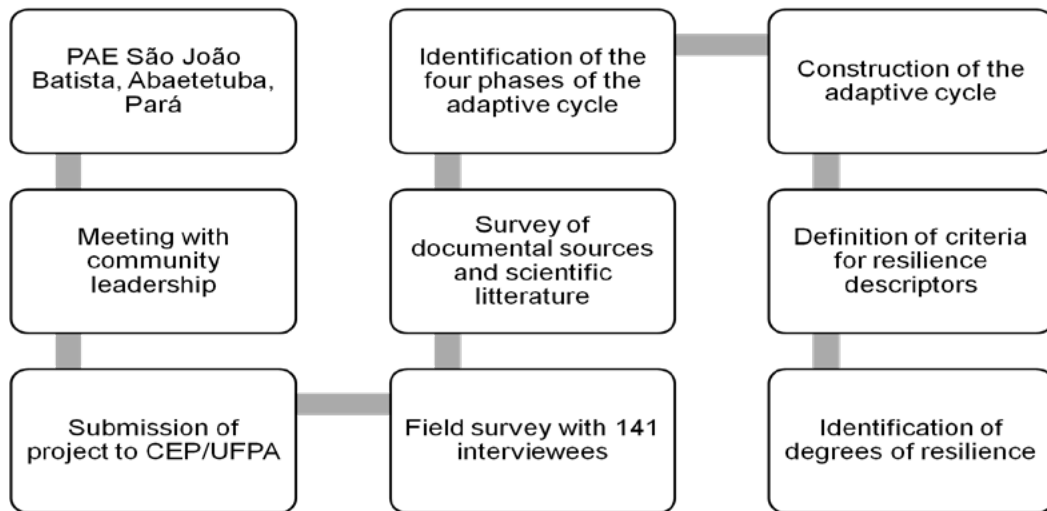


Figure 2 | Flowchart of the study in the PAE São João Batista, Abaetetuba, Pará.

3 RESULTS AND DISCUSSION

Along their historical trajectories (Figure 3), sugarcane and açai were necessary resources for the socioeconomic reproduction of the riparian communities in the PAE São João Batista, because it was through them that the process of territorial occupation and exploitation of natural resources took place, as well as changes in land use.

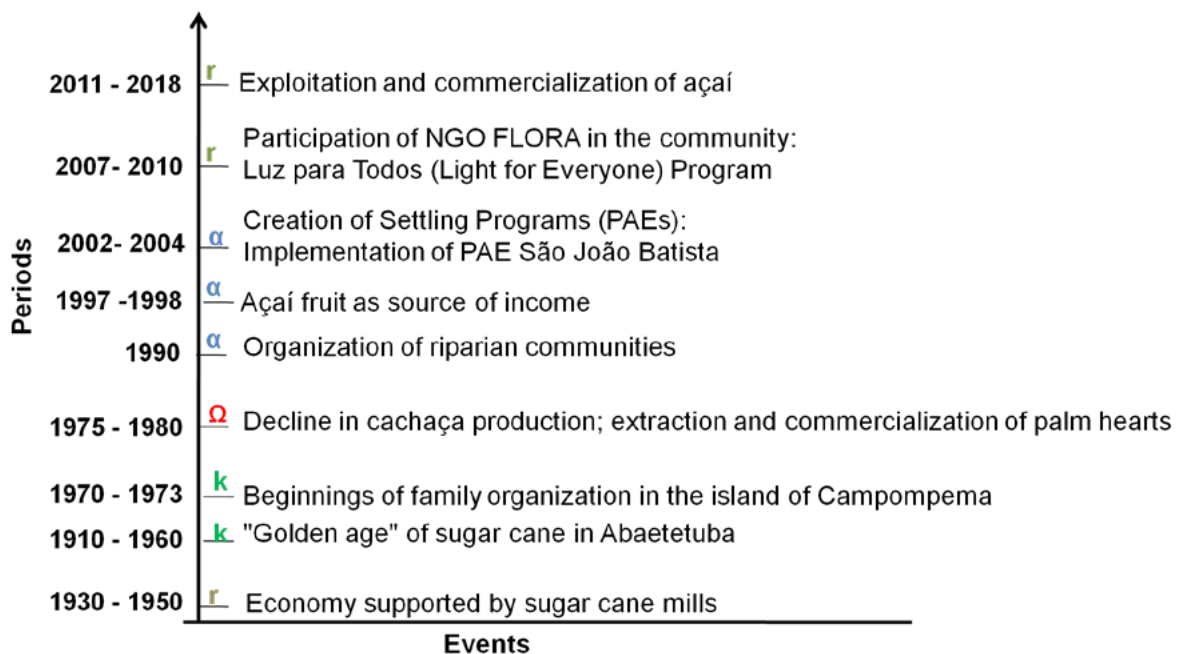


Figure 3 | Historical trajectory of the PAE São João Batista territory, based on the cultivation of sugar cane and açai respectively.

3.1 PHASES OF THE ADAPTIVE CYCLES IN THE PAE SÃO JOÃO BATISTA

3.1.1 SUGAR CANE – EXPLOITATION (r)

In 1930 the riparian dwellers from the island of Campompema worked in the Santa Cruz sugar cane mill. It belonged to Mr Murilo Parente Carvalho, located next to the Abaeté River, which remained in operation until around the 1960s and controlled the economic, social and environmental aspects of their lives, described as follows: “*The Santa Cruz mill produced lots of cachaça and its profits supported our life here in the community* (B. L. S., 83 yo.). “*There were no açaí sales, they sold cachaça*” (R. N., 74 yo.).

Sugar cane sticks were cut in pieces of about 80cm in length and piled up in the field in bundles that were carried and tied up in lots of ten, forming a *frasqueira* of cane (ANDERSON, 1991). *Frasqueira* was a unit agreed between the sugar cane collector and the mill owner for commercial transactions. In many cases, this agreement occurred in the form of a deal by which the mill owner would offer the land and the worker with his labour (NAHUM, 2011). The cane collector would get some financing from the mill owner to prepare the land, plant the cane, keep it in condition and then cut down the yield.

In exchange for an *aviamento*² of a sugar cane plot (done with consumption goods available at the mill’s store), the mill owner expected the cane collector to deliver his entire production. It was a person-to-person, informal arrangement that benefited only one-tenth of the farmers, and the workers without resources or *aviamento* were forced to become daily labourers (ANDERSON, 1991).

3.1.2 SUGAR CANE – CONSERVATION (k)

Together with other family mills, the Santa Cruz mill ensured the floodplain area population a stable income (ROGEZ, 2000), particularly in the 1960s, when the sugar cane yield had its “golden phase” in Abaetetuba. The increase in demand led to the installation of the first steam machines destined exclusively for the production of spirits (cachaça), whose quality was acclaimed all over the Pará State (MACHADO, 2008). However, the mills always operated following a primitive conception of production and economic relations and, over time, these means of survival declined.

In the 1970s, many workers resorted to the judicial system to claim their rights from the mill owners, and to avoid a larger social conflict, the State demanded the owners give away part of their lands in allotments to redress workers compensations (QUARESMA et al., 2015).

3.1.3 SUGAR CANE – RELEASE (Ω)

Planting and commercialization of sugarcane started to decline in 1975, as “*it was slave work, I earned three thousand réis [three cruzeiros] a week, then Labor Justice came and closed down the mill*” (R. N., 74 yo.). For some, “*life in the mill was tiresome, only the owner had profits*” (J. M., 56 yo.). Indeed, intensive labour was predominant in the mills, and cachaça production underwent a crisis; workers were not paid government incentives and were harmed the worst (QUARESMA et al., 2015). Furthermore, the precarious conditions of the mills, the refusal to replace the *aviamento* system with more modern practices, technological unreliability and the introduction of new labour laws all contributed to the overall deterioration (MACHADO, 2008; NAHUM, 2011).

The activities in the mills declined, “each of us began taking care of our plot” (J. M., 56 yo.), and as some *ribeirinhos* would not accept the current situation and demanded improvements, between 1970 and 1973 meetings began to happen involving representatives of the Catholic Church to discuss family organization in Campompema island. “Four residents were helped by the Diocese to create the community, they organized their families to be registered and be recognized (B.L.S., 83 yo.), so the São João Batista Community was created. The role of the Church was determinant in this process of territorialization of riparian communities, as it developed theoretical and practical political constructions to raise consciousness for the real situations that unleash oppression (GONÇALVES *et al.*, 2019).

The creation of the community coincided with the period of decline of the sugar cane production, a period in which the slowdown in the production of “cachaça” led the system to collapse, so the workers that depended on it were forced to look for alternative ways to survive, as “There was nothing, it was a situation of dereliction” (J. M., 56 yo.). Traditional food resources were exploited with increasing intensity: hunting became practically extinct, fishing did not bring much income; shrimp, which was a dietary complement, became subjected to predatory capture for resale; and whole açai groves were cut down to sell the heart of palm to factories located in the estuary (ANDERSON, 1991). Indeed, the destruction of the varzea forests with acai palms was so intense that state intervention was necessary through Law nº6.576/1978, which banned the felling of açai palm trees in the entire Brazilian territory – to little avail, as in 1980 the State of Pará became the main extractor and producer of canned hearts of palm in Brazil (MOURÃO, 2010).

3.1.4 RE-ORGANIZATION (α)

Intense exploitation of açai forests was associated with the informality of the occupation, like the federal administration of the territory allowed riparian communities to become vulnerable to third-party activities (ALVES, 2016). However, from 1990 on the Land Pastoral Commission (Brazilian acronym: CPT), the Basic Ecclesial Communities (Brazilian acronym: CEBs), the Union of Rural Workers (Brazilian acronym: STTRs), the Fishermen’s Colony and local associations got together to organize riparian communities towards recognition, demarcation and land titling (GONÇALVES *et al.*, 2016).

Simultaneously to that process of organization, the production pattern of açai would be altered from extractive to cultivated and/or directed management (FERREIRA, 2012). The growth of the açai fruit market in the 1990s caused a positive effect on its preservation and conservation (TAVARES; HOMMA, 2015). In 1997 and 1998, that fruit was an important source of income, especially due to the increasing demand in markets beyond the region, which ended up favouring the Rural Settlement Projects (Brazilian acronym, PAs) in the islands around Abaetetuba in 2002 (FERREIRA, 2012; GONÇALVES *et al.*, 2016).

The Agroextractive Settlement Projects (PAEs) anticipated the exploitation of areas provided with extractive riches through economically feasible, socially fair and ecologically sustainable activities in the Amazonian floodplains. In 2002-2004, populations that occupied or intended to occupy these areas would implement those activities (BRASIL, 1996). PAE São João Batista was implemented in 2004 in the island of Campompema, and one of its goals was to foster the productive chain of the exploited natural resources (ALVES, 2016).

3.1.5 AÇAÍ – EXPLOITATION (r)

During the exploitation and commercialization of sugar cane spirits (cachaça), açai production was geared toward family survival: açai fruit was collected and vines were cut off to ease its handpicking. The natural abundance of açai palms was little affected by humans, to whom they supplied enough for their domestic needs, and management was restricted to backyard clumps where the fruit was collected (MARINHO, 2009). This state of affairs, however, began to change with the progressive market demand for açai, which favoured the implementation of the PAE São João Batista in Campompema Island. According to locals, in 2007 and 2008 the non-governmental organization FLORA created a module of permanent planting of açai palm for the riparian community to strengthen forest conservation. In 2010 Campompema island was included in the Program Luz para Todos (LpT-Light for All), created by the federal government (Decree 4.873/ 2003) to increase income and promoting the social inclusion of benefitted communities by providing access to electricity (FREITAS; SILVEIRA, 2015). This program brought an electric energy to 41 residences (among the interviewees) who managed to register in the PAE São João Batista. Others who missed their registration live on energy regularly supplied by Centrais Elétricas do Pará (Celpa). There are also small private energy suppliers, altogether summing up 100 families who can enjoy electrical energy.

The settlement also harbours the actions of institutions such as the Movement for the Ribeirinhos and Ribeirinhas of the Abaetetuba Floodplains (Brazilian acronym: Moriva), the Movement for the Ribeirinhos and Ribeirinhas of the Settlement Projects (Brazilian acronym: Moripa), churches, the PAE São João Batista Association. More recently the Abaetetuba Town Hall implemented a system of water supply and distribution to the residents that helped the exploitation and commercialization of açai fruit in local and external markets. It is estimated that açai is the main source of income for 77% of the rural population in northeastern Pará (SANTANA et al., 2012).

Likewise, the riparian community of the São João settlement have açai as their basic source of income, which explains their appropriation of floodplain areas for management of açai palm trees: it was found to be so in 75% of the analyzes family establishments. Management of floodplain forests for açai production is done off-season (from January to July) and involves the felling of the tallest and least productive palm trees, cleaning the plot and then its enrichment with the planting of new açai palm trees. During this off-season period, the source of income for the locals is the selling of artefacts, fish and shrimp in local marketplaces and also official government money transfer programs such as *Bolsa Família*³.

The commercialization of açai fruit is done in local marketplaces or through the Abaetetuba Fruit Farmers Co-operative (Brazilian acronym: Cofruta), created in March 2002, in which eight ribeirinhos of the settlement take part (an informant). Besides Cofruta, through the agro-extraction of açai, the riparian communities aim to strengthen their production chain through access to microcredit and business advice. Thirteen per cent of *ribeirinhos* requested support from the Amazônia Florescer program (Amazonia Blossoming) of the Banco da Amazônia, so that a family could have resources to enhance the development of their extractive activities: for instance, 7% of the families were consolidating a partnership with the company “100% Amazônia” to be able to sell açai at its best price.

3.2 ADAPTIVE CYCLE AND RESILIENCE OF THE PAE SÃO JOÃO BATISTA

The historical process of occupation of the PAE is associated with the community’s ways of life in interaction with the floodplain environment and the production of sugar cane and açai palm. The importance of the historical trajectory is shown in the adaptive cycle about these cultivations (Figure 4).

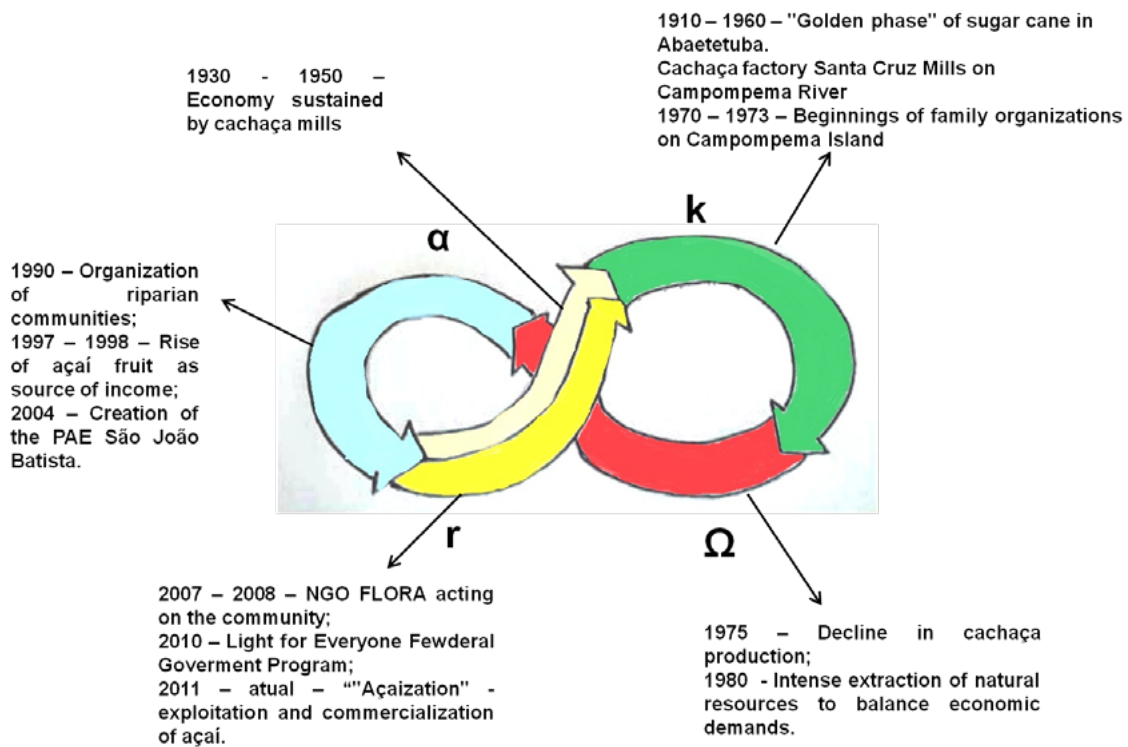


Figure 4 | Adaptive cycle with the historical trajectory of the PAE São João Batista, about the cultivation of sugar cane and açai respectively. Phases: r – exploitation; k – conservation; Ω – release and α --re-organization.

Table 2 shows the evaluation of social, economic and natural capitals and their respective association with socioecological resilience.

Table 2 | Evaluation of resilience in each phase of the adaptive cycle in the PAE São João Batista, Abaetetuba, Pará.

Phases	Social Capital	Economic Capital	Natural Capital	Value	Resilience	Land use
Exploitation (r)	Strong 1	Strong 1	Strong 1	3	Resilient	Sugar cane
Conservation (k)	Weak 0	Strong 1	Weak 0	1	Slightly Resilient	Sugar cane
Release (Ω)	Weak 0	Weak 0	Weak 0	0	Non-Resilient	Sugar cane
Re-organization (α)	Strong 1	Strong 1	Strong 1	3	Resilient	Açai
Exploitation (r)	Strong 1	Strong 1	Weak 0	2	Slightly Resilient	Açai

Source: Elaborated by the authors.

Sugar cane cultivation in this riparian community in 1930, in the exploitation phase (r), structured a production system around the mill, with intensive labour, an abundance of natural resources and a high degree of commercialization. Although dealing with a monoculture, that phase was considered "Resilient". With that cultivation, its potential (the possibility of system transformation) increased together with the growth of interrelationships, following into phase k. The latter was characterized by the economic prosperity caused by sugar cane and the unleashing of disturbances resulting from labour laws, competition with other markets and participation of *ribeirinhos* in social movements, culminating in the organization of the community. The economical capital in phase k is positive, but social and environmental capitals were negative; hence, this phase was considered "Slightly Resilient."

Agents of change led to the collapse of the system (phase Ω), and the extraction of açai palm hearts represented a reaction against sudden changes and created conditions for innovation. In this phase, all aspects are problematic, so it can be labelled "Non-Resilient".

The sugar cane cycle ends up reorganizing itself (phase α) taking advantage of opportunities such as the recognition and territorial demarcation of riparian communities like the PAE São João Batista, and the rise of açaí. *Ribeirinhos* showed an ability to organize themselves using plant extraction as a source of income, employment and social integration; therefore, it could be said that the phase of re-organization and current exploitation is “Resilient”.

The cycle starts all over (phase r), now with an economic foundation in açaí management and social and economic capitals both considered strongly developed. However, the natural capital is weak, as that cultivation is a monoculture and has caused soil degradation, poor water quality and a threat to local biodiversity, thus characterizing a phase of “Slight Resilience”.

On the other hand, the *ribeirinhos* are still dependent on a whole set of activities, such as the cultivation of medicinal species, particularly peppermint (*Mentha* sp.); catching fish and shrimp in rivers and streams, and handicraft making (Figure 5). This allows for new forms of adaptation and has led to a good level of resilience of the socioecological system, considering the number of changes they underwent. Furthermore, as the communities organized themselves into a form of settlement that attracted public policies and official support for production, we can acknowledge that settlement as “Resilient”.

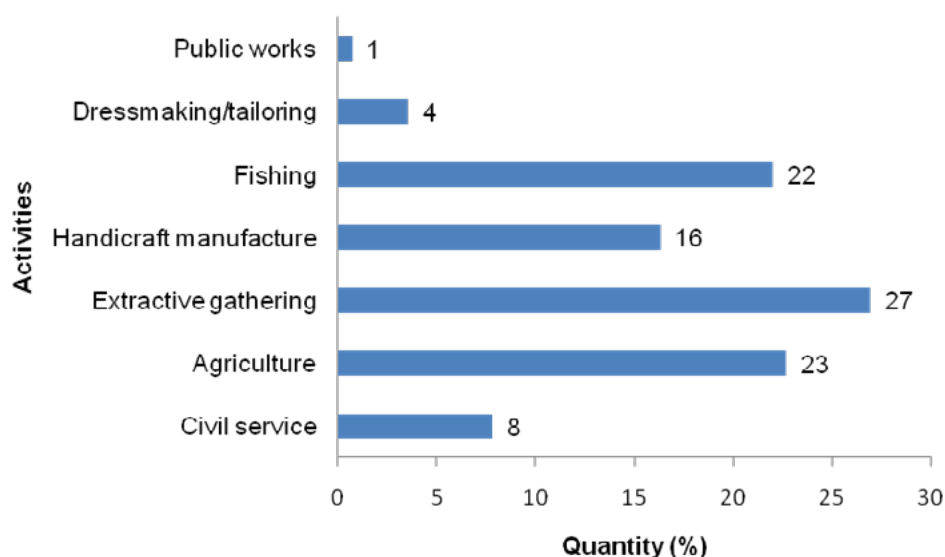


Figure 5 | Activities took by the riparian communities in the São João Batista settlement, Abaetetuba, Pará.

From a social standpoint, most of the community members remained in the settlement and adopted the extractive gathering of açaí fruit as their main activity, one that is expanding in the municipality and showed resilience to changes. Settlement policies, land reform and integration programs (such as *Bolsa Família*) indeed provided the necessary security in the period of disturbances in the SSE. Ecologically, although considered a low-impact activity, the exploitation of açaí changed to fulfil the increase in demand and, therefore, exerted pressure on floodplain forests and incurred an impact on biodiversity and the provision of ecosystem services.

The expansion of açaí planting to cram the floodplain forest areas where it already occurs naturally was regarded as a new way of development in the PAE São João Batista. Açaí is an important species for subsistence, for family income and to ensure land occupation, and signals the point of resilience in the community, which kept its structure and adopted the exploitation and commercialization of the fruit for self-organizing (phase α of the adaptive cycle). There was a potential for an unexpected and quick change that resulted in a process of positive feedback, maintaining its identity (BUSCHBACHER *et al.*, 2016). However, the environmental consequences of these changes have altered local biodiversity and landscape (GONÇALVES; BRASIL, 2016), due to the current extractive model practised by riparian communities in the Amazon estuary (FREITAS *et al.*, 2015).

3.3 “AÇAIZATION” AND THE FUTURE OF THE PAE

Increasing commercial demand for açaí fruit in Brazil and abroad made it the main source of income for the riparian communities in the Amazonian estuary. However, to survive in this ever-shifting market, agroextractivists intensified the management of açaí in the varzea forests. Such practices in the estuarine floodplain involve thinning of sprouts and cutting of trees around the clumps of açaizais to allow more access to light and make the plant more competitive and transplanting seedlings from those clumps into areas of spontaneous occurrence of açaí to constitute homogenous formations of the plant (TAGORE, 2017). This type of management leaves the environment subjected to threats that could affect its ecological system, especially when açaí becomes the dominant species in the settlement (Figure 6), a fact referred to by Hiraoka (1993) as “açaization”.



Figure 6 | Expressive presence of açaí (*Euterpe oleracea* Mart.) in the landscape of the PAE São João Batista, Campompema island, Abaetetuba, Pará.

Source: Elaborated by the authors.

The negative consequences of the intensive management of açaí in the PAE São João Batista have already begun to be perceived by the *ribeirinhos*, as statements such as the following often appeared in the interviews: “The soil started to crumble because of felling the trees.” (N. C. N., 32 yo.). “The land is lowering, tree roots are too much up there, so the tree loses its leaves, too much deforestation” (A. S. S. N., 64 yo.); “Açaí dries up in the tree because there is pollution, deforestation” (R. S. N., 74 yo.); “Açaí is hanging on up there, drying up, then it falls” (J. M., 56 yo.); “Animals are vanishing because they are killing the trees” (M. S. A. F., 55 yo.).

In the 1990s, the production of native açaí fruit that was due almost exclusively to extractive gathering began to include also those taken from managed and cultivated native açaí trees (NOGUEIRA *et al.*, 1995). The possibility of expanding the profitability of açaí production employing management by increasing palm densities in floodplains improved the income of families and kept the forest standing. Indeed, the goal of managing acai palm trees is to generate economic, ecological and social benefits to traditional communities (JARDIM, 2002): therefore, various techniques are employed to increase production and boost consumption and commerce (SANTOS JÚNIOR *et al.*, 2015).

The expanding demand for açai fruit has transformed a vast portion of the diverse riverine forest into a quasi-monodominant açai forest and the changes were perceived by the *ribeirinhos* as they expressed in the interviews. Intensification of management and exploitation of açai has resulted in the loss of over 50% of the diversity of tree species and a reduction of 63% in the number of pioneer species of the varzea forests (FREITAS *et al.*, 2015). Removal of tree species from the floodplain often leads to poor yield and quality of açai fruit, as the açai palm tree is strongly dependent on ecosystem services such as pollination: according to Campbell *et al.* (2017), the presence of bees, in particular, is larger in floodplain areas surrounded by dense vegetative cover.

Still, on the suppression of the native vegetation, the interviews evidenced deforestation in river margins due to the extinction of the riparian forest, causing deposition of sediment in rivers. Gonçalves and Brasil (2016) and Tagore *et al.* (2018) also pointed at that environmental problem and emphasized that the fall of native trees weakens the cliff sides and river banks, and therefore the erosion and deposition of large amounts of sediments in the river beds.

The environmental threats to the estuary floodplains previously described were driven by a public policy based on the use of natural resources. Even if the *ribeirinhos* improved the infrastructure of their residences and boats with the implementation of the PAE with the financing that allowed the expansion of the açai market, they faced new challenges with the preservation of the Amazonian estuary floodplain.

4 CONCLUSION

The history and the resilience of the community in the PAE São João Batista, Campompema island, Abaetetuba, Pará, are set in a given scale where the adaptive cycle reveals that the change (or disturbance) of the system occurred due to the decline in sugar cane yield. The transition of the economic system Sugar Cane-Açai elicited the ability of the *ribeirinhos* to experiment with changes and created conditions for their re-organization as a settlement.

The phases of the adaptive cycle of exploitation and growth, anchored in the use and commercialization of açai allowed by the settlement, classify the latter as “Resilient”. However, it is important to highlight the role of local institutions, public policies and the *ribeirinhos* in strengthening that resilience, as the challenge is to make them able to face periods of instability, taking advantage of the opportunities brought in by their productive activities such as fishing and the cultivation of other plant species, handicraft-making and cultural diversity.

In the current picture of increased pressure on floodplain forests for the production of açai, collective actions must be worked on to better articulate their yield and commercialization and to create new socioecological relationships. That would ensure conservation and maintenance of environmental services in the floodplain forest, and the permanence and sustainability of riparian communities who live on the extractive gathering of açai in their lands.

The adaptive cycle can be considered a heuristic model which, combined with resilience analysis, constitutes a useful tool to study the trajectory of socioecological systems in Amazonia and to identify possible determining factors of their changes and reorganizations. This would propitiate opportunities for planning in a context of quick and profound changes in the Anthropocene.

NOTES

¹ This paper follows Lira and Chaves (2016) and equally employs the words “riparian communities” and “ribeirinhos” to designate the residents of the PAE São João Batista, which is only accessible by inland waterway and whose way of life is identified by their use of forest and water resources.

² *Aviamento* was a system of credit focused on a commercial establishment that attached to the mill, where a primitive form of bookkeeping registered on a notebook the mill workers’ withdrawals and their yield. At the end of the month, the withdrawals were discounted from the salary previously settled with the mill owner (MACHADO, 2008).

³ *Bolsa Família* (Family Endowment) is a federal program of conditional transference of a stipend destined to poor families who meet certain conditions related to health and education (SILVA; PAES, 2019).

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