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Article

Climate Change and Socioecological Resilience: Perceptions of Traditional Communities in Brazilian Marine Extractive Reserves

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ABSTRACT
Traditional coastal communities are among the most vulnerable to the effects of climate change, despite having played no role in its emergence. This illustrates one of the key dimensions of climate injustice. To address this injustice, it is essential to implement public policies that facilitate climate adaptation, grounded in existing local governance structures, such as conservation units to which these communities are connected. It is crucial to comprehend these communities' perceptions of climate change and the available management tools. This study analyzes the perceptions of traditional communities in two Extractive Reserves (RESEXs): Corumbau, Bahia, and Caeté-Taperaçu, Pará, regarding various aspects of the climate emergency. The analysis is based on the results of semi-structured interviews conducted in 2021 and 2022. The interviews covered topics including social and ecological sensitivity, public policies, and adaptive capacity. The findings indicate that these communities recognize the significance and adverse effects of climate change, although they do not provide a precise definition of the term. For these populations, the impacts of climate change affect their livelihoods, and the current management arrangement does not represent their interests as local actors. The research findings indicate a clear deficiency in the actions of public authorities to facilitate dialogue between diverse forms of knowledge and to establish support structures in the event of emergencies. In the context of implementing public adaptation policies, it is essential to consider the socio-economic structures and the processes through which information is circulated and concepts are developed and articulated in the spaces where climate change adaptation instruments are formulated.
Keywords: climate injustice; climate vulnerability; traditional coastal communities; maritories.

RESUMO
Comunidades tradicionais costeiras estão entre as mais vulneráveis às mudanças climáticas, ainda que não tenham contribuído para o surgimento desse fenômeno, demonstrando uma das facetas da injustiça climática. Para combater essa injustiça são necessárias políticas públicas que promovam a adaptação climática, com base em arranjos de governança locais existentes, como unidades de conservação a que essas comunidades estejam ligadas. É essencial entender as percepções dessas comunidades quanto às mudanças climáticas e aos instrumentos de manejo disponíveis. Este estudo analisa as percepções relacionadas a diversos aspectos da emergência climática em comunidades tradicionais das Reservas Extrativistas Corumbau, Bahia, e Caeté-Taperaçu, Pará, com base na análise de entrevistas semiestruturadas, realizadas em 2021 e 2022, que abrangeram temas como sensibilidade social e ecológica, políticas públicas, e capacidade adaptativa. Os resultados mostram que essas populações reconhecem a importância e consequências negativas desse fenômeno, ainda que não articulem uma definição precisa do termo "mudanças climáticas". Para essas populações os impactos das mudanças do clima incidem sobre o seu sustento e o arranjo atual de manejo não representa os seus interesses como atores locais. A partir dessa pesquisa percebe-se a inexistência de uma atuação mais apropriada do poder público na promoção de diálogo entre os diferentes tipos de conhecimento e na construção de estruturas de apoio em casos de emergência. Faz-se necessário, no contexto de

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implementação de políticas públicas de adaptação, considerar estruturas socioeconômicas, entendendo como as informações circulam e como os conceitos emergem e são articulados nos espaços de formulação de instrumentos de adaptação às mudanças climáticas.
Palavras-chave: injustiça climática; vulnerabilidade climática; comunidades costeiras tradicionais; maretórios.

Introduction

Traditional coastal communities are among the populations most vulnerable to climate change, despite not having contributed to the emergence of this phenomenon, which highlights one of the facets of climate injustice (Brasil 2016; Mills 2020). The territories where these communities live—or their *maretórios*—are expressions of their connections with the coast and the sea, such that their very ways of life, including their identity, culture, and subsistence, are deeply intertwined with the surrounding environment (Nascimento 2021).

The concept of *maretório* has its origins linked to the social movements of coastal-marine extractivists in the state of Pará. According to Nascimento & Barboza (2020), it emerged in the 2000s with the aim of defining ways of life that do not operate solely within the logic of land, solid ground, and spatial boundaries. It presents three dimensions of understanding: spatial-relational; strategic-institutional; and identity-based (Sousa et al. 2024, p. 84). In this sense, it emerged as a form of recognition of the specific ways of being, existing, and resisting of coastal-marine extractivists, whose way of life—including cultural and work-related aspects—is intrinsically influenced/shaped by the dynamics of the tides, thus assuming identity-based dimensions necessary for the guarantee of rights (health, education, etc.) that acknowledge the reality and specificity of these peoples.

Timmermann et al. (2024, p. 100), in a study on public health policies in Brazil for the *povos da água* (water peoples), present a definition of *maretório* constructed by the extractivists themselves, highlighting the importance of ensuring that this definition includes the perceptions of these peoples:

> "[...] socially constituted spaces that encompass marine and adjacent land areas within coastal and marine ecosystems, which are essential for the cultural, social, economic, environmental, and labor reproduction of traditional peoples and communities, whether they are used on a permanent or temporary basis, and are guided by seasonal patterns characteristic of regions influenced by the tides" (Célia Neves, personal communication in Timmermann et al., 2024, p. 100).

Currently, the term maretório has also been used in other parts of Brazil and in different contexts beyond social movements, such as universities, research institutes, and NGOs. Several studies conducted with extractivist peoples along the Amazon coast have incorporated the concept and have been discussing its origin, meanings, scope, and significance (Pimentel 2019; Nascimento & Barboza 2020; Sousa et al. 2020; Nascimento 2024; Timmermann et al. 2024; Sousa & Moreira 2024).

Understanding the reality of coastal communities and their everyday challenges—whether related to climate change or not—including existing strategies to face present and future problems, is essential for strengthening local populations and public policies that contribute to their sustainability (Ostrom 2009). This knowledge serves as a foundation for assessing the degree of climate vulnerability of these communities.

The Intergovernmental Panel on Climate Change (IPCC) defines climate vulnerability as:

> "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (Field et al. 2014, p. 5).

In this regard, the Sixth Assessment Report (AR6) of the IPCC (2023) recently presented several findings. One of them is that the poorest and most marginalized communities are those that suffer the most from the negative impacts of climate change, despite contributing the least to the worsening of the climate crisis: 50% of the poorest households are responsible for about 15% of greenhouse gas (GHG) emissions, while the richest 10% account for 45% of emissions.

Countries located in Central America, South America, and Africa are highly vulnerable to climate impacts, and their intersecting social processes increase climate sensitivity while also hindering adaptation capacity in these regions. For example, between 2010 and 2020, the mortality rate from storms, floods, and droughts was 15 times higher in countries most vulnerable to climate change than in those less vulnerable (IPCC 2023).

Coastal cities and regions are on the front lines of climate change, facing multiple risks such as sea-level rise and erosion, increased frequency and intensity of extreme weather events—including cyclones, hurricanes, storms, floods, and severe droughts—, shrinking habitable spaces, salinization of aquifers and surface waters, and the degradation of basic sanitation systems, among others (IPCC 2023; Barange et al. 2018; PBMC 2016).

This conjunction of factors is increasingly driving displacement and involuntary migration, while also causing the destruction of homes and infrastructure, loss of property and income, deterioration of human health, and food insecurity, resulting in adverse effects on gender equity and social justice (IPCC 2023).

In socioeconomic terms, climate change has particularly affected the productive activities of coastal communities, especially fishing. Ocean acidification and warming, changes in rainfall patterns, and the fragmentation and loss of critical habitats—such as coral reefs and mangroves—alter species distribution and negatively impact fish production. These effects are especially harmful to small-scale fishers, limiting access to fishing resources, altering traditional fishing techniques and practices, generating user conflicts, and changing the dietary habits of local communities (Barange et al. 2018).

This is especially concerning in countries with many coastal cities, which must protect healthy ecosystems to support resilient livelihoods. The IPCC report also emphasizes the urgent need to close the adaptation gap and reduce greenhouse gas emissions (IPCC 2023).

Access to and use of information, economic and technological resources, and participatory governance—among other factors—directly influence the way in which the climate adaptation process occurs. This adaptation process requires support from municipal authorities; however, this is a challenging issue, since climate adaptation is not always a priority for local governments (Teixeira, Pessoa, and Di Giulio 2020).

The difficulty in implementing adaptation processes is one of the factors that characterize populations as vulnerable to the impacts of climate change. The main way to reduce climate vulnerability, identify the most at-risk areas, and prevent disasters is to observe climate change at the local level—that is, to understand how this exposure occurs locally, how communities experience these changes, and also how both communities and governments adapt to any necessary transformations (Marengo 2007; Neves et al. 2022).

Considering that traditional communities possess a distinct body of knowledge, accumulated over generations, about the environments in which they live, it is essential to recognize how they perceive climate change and its impacts on their ways of life and on natural resources. Therefore, it is necessary to strengthen local associations and raise awareness within communities about climate change (UN-BR 2015), so that they can be better prepared to face climate-related adversities.

Since 2023, the federal government has been developing the Climate Plan, which will act, among other fronts, on climate change adaptation. The plan involves collaboration with states and municipalities (MMA 2024) and includes civil society participation through the proposal and voting of initiatives via an online platform (Brasil online). However, due to differences between administrative levels, as well as other specific characteristics of the various regions of Brazil—even within a single state—it is likely that coastal populations will be impacted in very particular ways in terms of public policies focused on climate adaptation.

In addition, other governance mechanisms, such as conservation units—especially those in the sustainable use category—should add further complexity to the interaction among the various public instruments addressing the effects of the climate emergency. Therefore, a study is needed to systematize and compare the different realities experienced by populations along the Brazilian coast.

Several population groups inhabit the Brazilian coastline—among them, those formally recognized as traditional communities. The Brazilian Society for the Advancement of Science (2021), based on the National Policy for the Sustainable Development of Traditional Peoples and Communities, defines traditional populations as:

> "Culturally distinct groups who identify themselves as such, who possess their own forms of social organization, who occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral, and economic reproduction, drawing on knowledge, innovations, and practices generated and transmitted through tradition" (p. 24).

Indigenous peoples, *quilombola* communities, terreiro communities, Afro-Brazilian religious groups, artisanal fishers, extractivists, and coastal and marine extractivist communities, among others, are some of the

groups that make up the National Council of Traditional Peoples and Communities, established in 2016 (Cunha et al. 2021).

Traditional populations have their territories recognized, for example, through sustainable use conservation units. Within the category of sustainable use conservation units are the Extractive Reserves (RESEX). The management of RESEXs is shared between the federal government, local associations, and other actors such as research and educational institutions, technical assistance agencies, among others, through the operation of a deliberative council (Saraiva et al. 2012), with the Chico Mendes Institute for Biodiversity Conservation (ICMBio) being the agency responsible for their administration (Brasil 2000).

In this context, the main objective of this study is to understand how traditional communities of the Corumbau (BA) and Caeté-Taperaçu (PA) Marine Extractive Reserves perceive climate change and its effects on their livelihoods. In parallel, it seeks to understand local conceptions of climate change and whether these communities believe that climate change is already affecting their ways of life.

This study analyzes the vulnerability of these communities to climate change, with a particular focus on exposure, adaptive capacity, and ecological and social sensitivity. The findings show how these populations perceive the existing public policies and offer insights to support the development of new public policies aimed at the climate change adaptation of highly vulnerable coastal traditional communities.

Methodology

Study Areas

The vulnerability of traditional populations was studied in two Marine Extractive Reserves (RESEX) along the Brazilian coast: the Caeté-Taperaçu Marine Extractive Reserve and the Corumbau Marine Extractive Reserve (Figure 1).

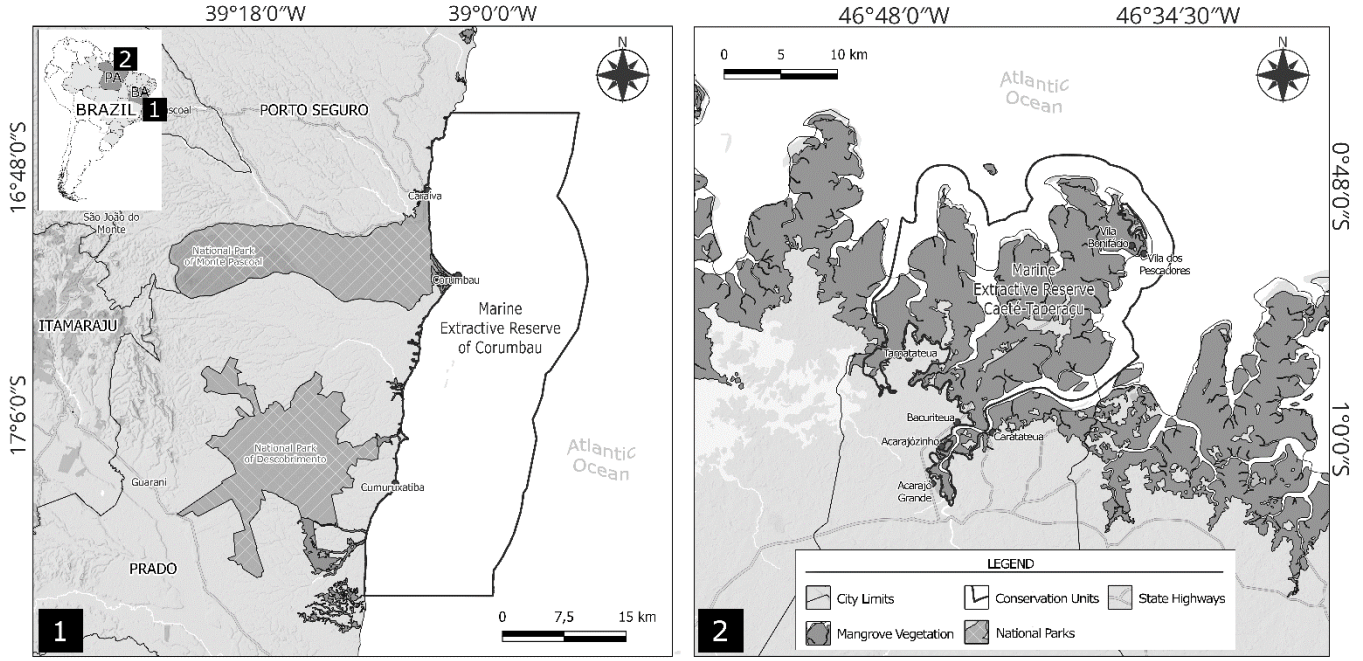

Figure 1. Location of the study areas. 1 – Corumbau Marine Extractive Reserve (Bahia). 2 – Caeté-Taperaçu Marine Extractive Reserve (Pará). Source: Authors' own elaboration.

The Caeté-Taperaçu Marine Extractive Reserve (RESEX-CT) is located on the northeastern coast of the state of Pará, along with 13 other Marine Extractive Reserves (RESEXs). In addition to hosting the largest concentration of extractive reserves in the country (ICMBio online), this region is home to the world's largest continuous mangrove belt (Nascimento et al., 2013) and includes the Ramsar Site "Amazon Estuary and its Mangroves" (Ramsar Sites Information Service online), a wetland of international environmental significance.

RESEX-CT, established in May 2005, spans an area of 42,000 hectares, occupying about 20% of the municipality of Bragança. Approximately 50% of its territory is covered by mangrove forests, considered among

the most well-preserved in the country (Abdala et al., 2012). The reserve benefits around 55 communities, organized into eight community hubs (Saraiva et al., 2012).

The Corumbau Marine Extractive Reserve (RESEX-CO) was established in September 2000 and is located in the far south of the state of Bahia. Its northern boundary is Espelho Beach in Porto Seguro, and its southern boundary is Ostras Beach in the municipality of Prado. The reserve covers an area of 90,000 hectares and is part of both the "Discovery Coast" and the "Whale Coast" (Brazil online).

RESEX-CO includes part of the main breeding area for humpback whales. From July to October, tourist whale-watching expeditions are conducted from RESEX communities, especially from Cumuruxatiba. Some species of sea turtles also nest on the beaches in the region. In both cases, these are species listed on the Official List of Threatened Species (Brazil online). Well-preserved mangrove ecosystems can be found at the mouths of the Caraíva, Corumbau, and Cahy Rivers (Brazil online).

Methods

Research Context

Data were collected in 2021 as part of the Maretório Project—a research and outreach initiative developed through a partnership between UFPA and UFSB, launched in 2021. The project's fieldwork phase (2021–2022) was funded by the British Council, a UK research funding agency. Data for RESEX-CT were collected in 2021 and 2022 in partnership with the NGO Rare Brazil and the Association of Users of the Caeté-Taperaçu Marine Extractive Reserve (ASSUREMACATA), through the project Clima para Sempre, funded by the Casa Socioambiental Fund.

Approach

This study adopts a qualitative-quantitative and applied research approach. It is descriptive and explanatory in nature and employs bibliographic, documentary, and field research procedures. Understanding the methodological aspects adopted requires familiarity with several concepts, explained below.

One of the first steps toward adaptation is reducing the vulnerability and exposure of communities to climate variability. Vulnerability refers to the propensity to be adversely affected and includes susceptibility to harm as well as limitations in coping and adaptive capacity. Exposure, on the other hand, refers to the presence of people, livelihoods, species, ecosystems, and other assets in places that could be adversely affected (IPCC, 2014).

Based on the dimensions of climate risk (IPCC, 2023) and the concepts of vulnerability and exposure described above, a semi-structured questionnaire was developed in collaboration with community leaders, universities, and local partners. This questionnaire formed the basis for conducting in-person semi-structured interviews with users of the RESEXs. The questions mainly addressed the concepts of exposure, social and ecological sensitivity, and adaptive capacity.

Social sensitivity aims to assess how the socioeconomic system may be disrupted or affected by climate change, primarily considering the local population's dependence on fishing-based livelihoods. Ecological sensitivity, in turn, is defined as the degree to which local biological systems—on which the community depends—can be affected by climate change (FishForever, 2019).

The next section, titled "Perceptions of Climate Change – Exposure and Ecological Sensitivity", discusses ecological aspects related to climate change. It addresses local perceptions regarding climate change, its causes, and impacts, considering factors such as geographic location, income, knowledge, and awareness, through eight questions.

To understand how the term "climate change" is interpreted by respondents, we analyzed whether answers to the question "What is climate change?" included elements of the following definition, developed for this study:

> **CLIMATE CHANGE** refers to (1) the changes that have been occurring in climate characteristics in recent decades and (2) that have caused modifications such as in the temperature of the air, seas, and rivers, and in the intensity of rainfall. These changes may have natural causes, but (3) they have been happening more intensely and rapidly due to some human actions that emit (4) gases that heat the planet, such as (5) deforestation, burning, the use of petroleum-based fuels, among others.

The next section focuses on social sensitivity, which is essential for the development of public policies and effective communication strategies for promoting climate action and sustainability. This section will also present socioeconomic characteristics such as the respondents' level of education, place of residence, income, and occupation.

Finally, the last section will present how communication and public policies can facilitate the population's adaptation to the impacts of climate change and mitigate its consequences. It will address the community's sources of information, perceptions of the importance of public sector involvement, the existence of local public policies, and the understanding of the RESEX's contribution to mitigating the negative effects of climate change.

This section will also address the adaptive capacity of these populations to climate change, which is defined as the ability of the local system to prepare for, respond to, and recover from such changes (FishForever, 2019). It is generally measured by the resources available to support recovery—through developed plans, available resources, resilient infrastructure, and the effectiveness of governance. The analyzed questions sought to understand how prepared the communities are in the face of the impacts and risks of climate change.

Data Collection

At RESEX-CT, 301 people were interviewed; however, not all questions were answered by every respondent, resulting in a different number of responses for each question analyzed. The interviews were conducted by local community monitors who had been previously trained through virtual and in-person sessions addressing climate change and the understanding of the research instrument. Aiming for spatial distribution in the sampling, one community from each cluster was selected to participate in the research. Monitors were instructed to seek a balance between male and female interviewees, using random selection.

At RESEX-CO, 30 members of the Cumuruxatiba Fishers' Association were interviewed. In dialogue with the leadership of the fishers' association, an initial list of people to be invited for the interviews was prepared. From these first participants, sampling continued using the "snowball" method (Goodman, 1961). The 30 interviews were conducted individually by three trained undergraduate research fellows. A focus group (collective interview) was also conducted with the participation of one fisher leader and three fishers, aiming to explore in greater depth the themes addressed during the individual interviews.

The difference in sample size between the two RESEXs was due to the partnership with Rare and ASSUREMACATA, which made it possible to carry out a greater number of interviews at RESEX-CT. This difference may influence the interpretation of some comparative analyses of the results.

All participants signed a Free and Informed Consent Form (FICF), after being informed about the objectives and procedures of the research. This study was approved by the Human Research Ethics Committee of the Federal University of Southern Bahia (UFSB), under the ID CAAE: 48434021.0.0000.8467, as well as by the Authorization and Information System on Biodiversity (SISBio), under number 79276-1.

Data Analysis

Both quantitative data (closed-ended questions) and qualitative data (open-ended questions) were produced and analyzed using Microsoft Excel©. The interviews were transcribed and systematized into tables. Then, a content analysis (Bardin, 1977) of the data was carried out, based on the research objectives.

Results

Perception of Climate Change – Exposure and Ecological Sensitivity

In general, the two RESEXs converge in terms of community perceptions regarding climate change and recognition of its influence on their lives (56% for RESEX-CO and 57% for RESEX-CT), even though most participants did not present a clear definition of the term (see data below). This perception suggests an awareness of the importance of understanding and dealing with environmental impacts. People from both RESEXs mentioned, for example, the increase in temperature as one of the main perceived climate changes.

The questionnaire also sought to understand whether the interviewee had a formulated definition of what climate change is. In RESEX-CO, when asked what climate change would be, 53% of participants offered a

definition different from the one established for this study or elements of it, 25% gave examples of the consequences of climate change, and 13% mentioned examples of human activities that cause global warming.

Similarly, in RESEX-CT, 49% did not provide a definition of the term or gave one lacking any of the elements in the definition formulated for this study, 29% gave examples of the consequences of climate change, such as "increase in temperature," "heat," and "increase in rainfall," and 9% gave examples of human activities that cause global warming, such as "deforestation" and "pollution."

Approximately 77% of interviewees in Corumbau and 66% in Caeté-Taperaçu reported that fish catches had decreased in the past 10 years. Among these, the majority (55% in RESEX-CO and 79% in RESEX-CT) attributed this change to the impacts of climate change. This indicates a shared perception of the negative effects of climate on fishing activities in both regions.

In both RESEXs, interviewees expressed concern about the threat that climate change poses to natural environments, with mangroves highlighted by 25% of participants in Corumbau and 26% in Caeté-Taperaçu. This demonstrates an awareness of the importance of ecosystem conservation and an understanding that these environments are subject to risks arising from climate change, even though there may not be a clear idea of the concept of this phenomenon. Interviewees from RESEX-CO and RESEX-CT mentioned species extinction, habitat destruction, and reduced fish harvests as the main negative impacts of climate change.

Considering both RESEXs together, nearly all interviewees believed that climate change is occurring in the region (93%). Among them, 83% indicated that air temperature had increased; 73% pointed out that rain and storms had decreased; 53% believed that the seas were rougher; 87% thought that flooding had decreased; and 63% reported that the coastline had receded. Additionally, 46% of the interviewees stated that deforestation is one of the human activities that intensify climate change.

All interviewees stated that the community environment had changed since they were children or since they moved there. Regarding the most significant changes in the past 10 years, most pointed to rising tide levels, deforestation, and species loss as the main ones. Species loss was mentioned by 22%, while 16% mentioned population growth and "other" changes.

Among the interviewees, 70% believed that fish catches had decreased in the 10 years prior to the survey, and among these, 55% attributed the change to the impacts of climate change. Around 73% of respondents felt that natural environments were threatened by climate change. At the local level, 25% of participants indicated that mangroves were the main natural environments threatened by climate in the region, followed by springs (24%).

Regarding the negative impacts of climate change on biodiversity, the following were identified: fish as the most threatened group (70%); species extinction and habitat destruction (16%); reduction in fish harvests (15%); changes in air temperature (10%) and changes in water temperature (10%).

Perception of Climate Change – Socioeconomic Profile and Social Sensitivity

The results show that, for both RESEXs, fishing is an important economic activity, suggesting a dependence on the natural resources available in the region. The main natural resources harvested in both reserves were marine fish and crustaceans. In addition, there is tourism activity on coral reefs and beaches.

In both RESEXs, household income is predominantly low, with most residents earning up to one minimum wage (at the time, R$1,100). A large portion of respondents had lived in the RESEX since birth, indicating a strong connection and bond with the place. In both RESEXs, there are associations that play an important role in community organization, and many of the interviewees are members of them (see percentages in Table I below).

Table I – Comparison of the socioeconomic profile of users of the Corumbau and Caeté-Taperaçu extractive reserves, as well as their perceptions regarding the social sensitivity of the RESEXs and the communities where they live.

	Corumbau	Caeté-Taperaçu
Main source of income	Fish fishing (51%), shellfish (38%), agriculture (9%), and crab (2%)	Fish fishing (32%), crab (21%), shellfish (18%), and agriculture (20%)
Level of education	Primary education (50%), Secondary education (30%)	Primary education (60%), Secondary education (27%)
Household income	Up to one minimum wage (73%)	Up to one minimum wage (94%)
Registered in the Parent Association or a Local Association	90%	74%
Gender	Men (97%)	Men (55%), women (39%), and no response (6%)
Age	40 years old or older (74%)	30 to 49 years old (52%)
Expected impact of climate change on income	83% of participants stated that climate change could negatively impact their main source of income.	54% of respondents believed that the impacts of climate change could negatively influence their main source of income.

Source: Own elaboration.

Perception of Climate Change – Adaptive Capacity, Communication, and Public Policy

The lack of trust in the representation of community interests within the RESEXs regarding local fishery management may indicate a general perception of low participation and influence in these decisions (see Table II). Furthermore, the limited use of mobile phones in emergency situations (47% have used mobile phones in Corumbau and 34% in Caeté-Taperaçu) suggests that, despite having access to the technology, people do not view mobile phones as useful tools in such circumstances—possibly due to cultural practices of relying on support networks such as neighbors, or even due to a lack of knowledge about this technology or limitations in coverage and connectivity. Additionally, in both RESEXs, there is strong trust in support networks (83% in Corumbau and 90% in Caeté-Taperaçu).

Respondents from both RESEXs consider the creation of the conservation unit to have been beneficial (65% in RESEX-CT and 64% in RESEX-CO). However, it is possible to infer that the communities of Caeté-Taperaçu have a more positive perception of the effects of creating the RESEX when compared to the community of Corumbau (in Corumbau, 33% stated that the creation of the RESEX did not change life in the communities, while in Caeté-Taperaçu this number was only 11%).

The changes resulting from the creation of the RESEX were different in each conservation unit. The monitoring of natural environments—which can be understood as protecting fauna and flora, combating illegal fishing, and other activities aimed at ensuring the conservation and sustainable use of natural resources essential to the communities' livelihoods—was considered more relevant in Corumbau (45%), whereas improvements in housing (37%) were more emphasized in Caeté.

Regarding access to information, both communities show similar behavior: in both Corumbau and Caeté-Taperaçu, television and the internet are widely accessed and used (in Corumbau, more than 60% combined; in Caeté-Taperaçu, more than 50% combined).

In RESEX-CO, around 47% of participants reported not believing that their interests are represented in the management of the territory where they live (councils, committees, fisherfolk colonies, local government), while 40% believe they are, and 13% did not know how to respond. About 67% of respondents stated they feel benefited by the decisions made in the RESEX regarding fishing. 83% of participants said they feel represented by the management of the territory in which they live.

The majority of participants in Corumbau (90%) and Caeté-Taperaçu (84%) consider the role of public authorities important in solving identified problems and in the conservation of the environment and people's livelihoods. This suggests a shared expectation regarding public power and its responsibility in managing and protecting these areas. Enforcement, awareness, and conservation were mentioned as possible approaches to address the environmental and social challenges faced by both RESEXs. This perception highlights the importance of the RESEX as a potential tool to deal with these issues.

Table II – Comparison of the perceptions of users of the Corumbau and Caeté-Taperaçu extractive reserves regarding communication among people and with public authorities and associations representing RESEX users, as well as aspects of adaptive capacity and public policies related to climate change.

	Corumbau	Caeté-Taperaçu
Relevant public policies	Do not exist (53%)	Do not exist (58%)
The creation of the RESEX is seen as a positive change	64%	65%
Importance of the RESEX in addressing climate change	63%	49%
Do not have financial resources to deal with environmental disaster situations	80%	84%
Feel their interests are represented in territorial management	47%	39%
Whom they would ask for help in environmental disasters (multiple answers possible)	Neighbors: 83% RESEX users' association: 24% ICMBio: 21% City government: 17%	Fire department: 72% Civil Defense: 14% ICMBio: 14%
Main source of information or knowledge	TV: 34% Internet: 33%	TV: 41% Radio: 19% Internet: 15%
Cell phone use	Have a cell phone: 100% Used in emergencies: 47%	Have a cell phone: 91% Used in emergencies: 35%

Source: Own elaboration..

Discussion

Indigenous and traditional populations play a fundamental role, on a global scale, in the preservation and sustainable use of biodiversity (Cunha et al., 2021). Garnett et al. (2018) found that Indigenous peoples contribute to the management and conservation of approximately 25% of the Earth's surface, which hosts 35% of the planet's most protected ecosystems, in addition to being responsible for 35% of protected areas.

Although many areas of the planet are considered protected, including those managed by traditional populations, the Intergovernmental Panel on Climate Change (IPCC, 2023) states that climate change caused by human activities is already occurring in all regions of the world. This is resulting in weather and climate conditions that cause negative impacts, losses, and damage to both nature and people. Climate change has already caused excessive and irreversible damage in terrestrial, freshwater, coastal, and open ocean environments, among others. One example is the loss and disappearance of hundreds of local species due to rising temperatures and extreme heat (IPCC, 2023).

The negative influence of human activity on the atmosphere, oceans, and soil is evident, and the most vulnerable communities – coastal and traditional – are the ones most affected by climate change, even though they have historically contributed the least to its causes (IPCC, 2023). The findings of the present study illustrate this impact through the perceptions of traditional populations on the Brazilian coast.

Most respondents from RESEX-CO and RESEX-CT are aware of the dangers of climate change, a finding also observed in other coastal contexts in the Global South (Alam & Mallick, 2021; Ehsan et al., 2022). This does not necessarily mean they have in their epistemological repertoire detailed knowledge of the term, its causes, or its main impacts, which are more commonly addressed in scientific or technical contexts. However, these individuals have some level of contact with meanings and associations related to the term "climate

change" – or "climate shifts" – which originate in academia and reach them through television, radio, and the internet in general. The fact that they live in coastal areas may explain this high level of exposure to academic and technical epistemology, since a previous study found a positive relationship between coastal proximity and belief in the reality of climate change (Milfont et al., 2014).

Hanai & Netto (2005) observe that human perception is a fundamental requirement for achieving various levels of environmental awareness. In seeking to understand these perceptions in relation to scientific and technical aspects of climate change, this study does not aim to assess how complete or accurate these local perceptions are. Rather, it seeks to understand the degree of alignment between local knowledge and academic epistemology in order to evaluate the need for dialogue between these two forms of knowledge and emphasize the importance of ongoing dialogue between traditional and scientific knowledge. Collaboration based on both popular and scientific understanding has greater potential to enable effective nature conservation. Moreover, climate change is advancing more rapidly and severely than models had previously indicated, requiring constant monitoring and highly adaptable management models – to which the perceptions of these traditional populations can contribute significantly.

In addition to pointing out the effects of climate change already occurring along the Brazilian coast, the study of traditional populations' perceptions also points toward possible solutions. For these communities to be able to adopt adaptation and mitigation strategies, there is a need – as mentioned above – for an epistemological dialogue on climate change, bringing together academic discourse and public policy with traditional local knowledge.

Beyond definitional matters, interviewees from both RESEX-CO and RESEX-CT perceive that climate change impacts could negatively affect their sources of income. Rain and storms, wind, and species loss were cited as the main impacts. These communities also noticed that natural environments are being threatened, especially mangroves, beaches, and flooded fields. According to respondents from RESEX-CT, the most endangered groups are mammals and fish. The main negative impacts of climate change on biodiversity identified by these populations include reduced fish harvests, habitat destruction, and species extinction.

Traditional peoples and communities maintain a deep and historical relationship with nature, not only based on economic subsistence or environmental conservation but also on valuable cultural knowledge and practices. These cultural perspectives are frequently ignored and undervalued (Conselho Pastoral dos Pescadores - CPP, 2016), including by public institutions in Brazil.

Although their ways of life are not always recognized or incorporated into public policies, many respondents value public sector involvement in improving quality of life and environmental preservation. However, about half of the respondents do not identify any specific public policy as relevant. This perceived lack of climate-specific public policy, combined with low household income and the absence of financial protection against climate disasters, highlights the high socioecological vulnerability of the populations in the two RESEXs studied.

Nonetheless, the RESEX, as a management instrument that can also contribute to climate change adaptation, plays an important role. Its main objective is to preserve the livelihoods of traditional local populations, serving as an example of an instrument that values and incorporates cultural aspects in public decision-making. In RESEX-CT, the general perception is that the RESEX can play an important role in mitigating adverse environmental impacts, particularly through environmental awareness, enforcement, and the creation of initiatives and collaborations.

Efforts to address the effects of climate change can be aligned with and learn from housing policies in the RESEXs. Despite criticism of the housing policy model implemented in RESEX-CT (Partelow et al., 2018), Alves et al. (2022, p.12) point out that "housing credit policies have potential that, when managed with local populations and integrated with other basic rights policies, can help mitigate social and environmental inequalities in the Reserve." In this study, residents of Bragança mentioned housing credit policies as improvements brought about by the creation of RESEX-CT, although they did not directly relate them to environmental issues. Still, housing policy is directly linked to climate change, for example, when homes are allocated based on flood or landslide risk zones. In any case, public policies must consider regional differences, especially the specificities of traditional populations, and must be adapted to climate change, with infrastructure adjustments that address the risks posed by such changes.

In addition, public policies are needed to promote the sustainable management of the RESEXs, strengthen communities' adaptive capacities, and effectively preserve local ecosystems. For example, investing in

community-based monitoring programs could strengthen RESEX-CO and RESEX-CT by ensuring adequate resources for environmental management, helping restore community trust in these conservation units, and tackling the various vulnerabilities they face. The results show a clear lack of trust in institutions directly linked to the RESEX, such as the users' association and ICMBio, both because people do not feel their interests are represented and because they do not consider asking these institutions for help in case of climate disasters.

It is also concerning that the RESEX itself, its affiliated organizations, and council meetings are not seen as sources of information for these communities. It is necessary to implement educational campaigns within the communities focused on raising awareness about climate change, emphasizing the importance of ecosystem conservation and promoting sustainable practices. Moreover, financial support programs should be implemented for community-based projects aimed at climate adaptation, and the RESEX can offer important communication platforms to foster dialogue on climate change. More than simply empowering or informing these populations, it is essential to generate income opportunities that guarantee the appropriate use of these marine-coastal territories, support the continuation of traditional ways of life, and ensure a dignified existence. After all, the people living in these areas are responsible for their conservation. The state plays a key role as facilitator of the proper functioning of the RESEXs, but should not act as guardian of local users, since RESEXs are managed under a co-management scheme in which users and the broader civil society must deliberate and manage through a deliberative council (Brasil, 2000).

Many of the effects that impact traditional communities are directly linked to environmental degradation, such as deforestation and other activities that alter ecosystems and reduce their capacity to respond to climate change. These communities are affected at multiple levels and fight not just for their individual interests, but because they are deeply connected to nature (CPP, 2016). This likely also explains their awareness of climate change and its effects, and their key role in overcoming climate vulnerabilities.

The context in which this research was conducted, in 2021 and 2022, differs significantly from the current post-pandemic context, which, although fragile, shows signs of political and economic improvement. However, the authors' experience in these RESEXs points to the persistence of many challenges, as evidenced by the slow resumption of investment in the RESEXs and a still inadequate situation in agencies such as ICMBio and IBAMA. Despite visible improvements, there is still a strong potential for growing disappointment with the current federal administration, which is responsible for managing and funding the RESEXs.

The catastrophe caused by the heavy rains in May 2024 in Rio Grande do Sul exposed Brazil's major shortcomings in preparedness for climate change, especially in terms of adaptation. Not only is investment lacking, but there are also gaps in data concerning the socioeconomic structure of vulnerable and marginalized populations. It is hoped that this study has contributed not only to filling some of these gaps, but also to serving as a foundation for future research or for updating existing studies such as this one.

Final Considerations

Considering social and ecological sensitivities, the results of this research suggest that both RESEX areas are in a situation of climate vulnerability.

In general, the people interviewed from both RESEX recognize the influence of climate change in their lives, although many did not provide a definition close to the scientific term. Moreover, they also demonstrate an understanding of the importance of preserving ecosystems and of the risks to which these ecosystems are exposed due to climate change.

The communities mentioned monitoring, awareness-raising, and preservation as possible approaches to address the environmental and social challenges they face. Monitoring, awareness, and environmental preservation actions are part of the general objectives of all Brazilian RESEX areas; therefore, there is an opportunity for RESEXs to act in order to meet this demand at the local level.

In a scenario of weak dialogue among different social groups and widespread distrust towards the government and management experienced through the RESEX model, the chances of significant economic, social, and environmental impacts are high, especially for communities already marginalized and made vulnerable by predatory and exclusionary development models.

A course correction is urgent to prevent new climate disasters.

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