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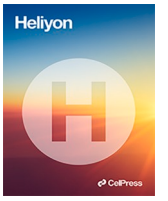

Are perceptions of climate change in Amazonian coastal communities influenced by socioeconomic and cultural factors?☆

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ABSTRACT

Climate changes have become undisputed, as have their consequences for global ecosystems and mankind. The coastal areas are among the most affected areas on the planet due to their geographical location. The effects suffered by coastal areas can render the residing populations homeless, as well as compromise the continuity of the history and culture of these environments. The Marine Extractive Reserve of the city of Soure (coastal area of eastern Amazonia) stands out for housing populations that have developed an intimate relationship with nature and have knowledge that can explain people's perception of climate changes. In this context, this study investigated how local residents perceive climate change and its consequences considering different temporal and spatial scales. To this end, questionnaires were developed and applied using a 5-point Likert scale. Our results indicate that perception is shaped by socioeconomic and demographic factors, and that they are perceived on different time scales and geographic space. These findings reflect the awareness-raising efforts of the management body of this Conservation Unit and the local knowledge, derived from the relationship of the residents with the natural environment, which, together, provided the population with assertive information that favor a better understanding of this phenomenon.

1. Introduction

Climate changes are defined as a modification in the state of the climate that can be identified by changes in the mean and/or the variability of climatic parameters that persist for a long period of time, typically decades or longer [1]. The perceptions of these changes have been widely studied along with climatological studies [2,3] to better understand the phenomenon and possible community responses to these changes. However, the methods used to capture and analyze these insights vary widely [4], limiting the comparison and integration of the results, and restricting the coherent and cumulative understanding of the phenomenon [5] (see Fig. 1).

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In this field of study, focusing on a specific context is an excellent path towards a more comprehensive understanding of climate perception [7]. Studies designed from the Theory of Construct Levels (TCL) provide important information through different dimensions of psychological distances, supporting the understanding of how these dimensions can affect decisions and the behavior of individuals [8]. People understand that climate change is real, caused by society, and that it will have negative consequences. Yet they may not engage in mitigation and adaptation initiatives if they believe that these consequences will take place far away in time and/or space [9,10]. Thus, studying peoples' perceptions broadens compression, as it enables access to different perspectives of psychological distance, specifically, temporal (when something happens), spatial (where it happens), social (for whom it happens), and hypothetical (whether it is likely to happen) distances [11,12].

Studies considering TCL have been conducted on several different countries and regions of the world, including Pakistan [13,14], Italy [15], England [16], Germany [17], the United States [18], the southwestern United Kingdom [19] and Southern Africa [20]. Combining climate perceptions with the psychological distance approach, these studies provide results that demonstrate that the more temporally, spatially and socially close the interviewees are in terms of how they view the phenomenon, the more willing they are to accept and participate in actions to mitigate and combat the effects of climate change.

Coastal communities tend to perceive climate change and see it as a threat to their permanence and local survival given its occurrence [21–24]. The Marine Extractive Reserve of Soure (Resexmar Soure) is a traditional coastal community located in the eastern Amazon [25]. The populations that reside within the community perform sustainable practices of use and management of natural resources [26]. Such, activities derive from their close relationship with nature, and from the awareness activities carried out by the Chico Mendes Institute for Biodiversity Conservation (ICMBio) in partnership with Teaching and Research institutions through projects focused on Environmental Education [27]. Climate change threatens the communities residing in this Conservation Unit due to its coastal location [28]. In addition, studies show that climate changes are already taking place in the region [29,30]. In addition, the Amazon region has been experiencing considerable increases in mean air temperature [31–33] and reductions in precipitation patterns [34], indicating that the effects of climate changes are already being experienced in the different ecosystems of this biome.

Based on evidence that point to regional changes in weather patterns and the local knowledge present in the communities, we sought to understand the perceptions about the climate in the Soure Extractive Marine Reserve. We adopted the Construal Level Theory [35] for a better and broader understanding of the phenomenon. The study was guided by the following questions: 1. Is the population of the Soure Marine Extractive Reserve able to perceive climate change and link its main causes? 2. Are these changes perceived locally and/or globally? 3. do these changes occur in the present or will they be a future problem? 4. Are they shaped by any socio-economic and/or cultural factors? The study was conducted by applying forms containing 5-point Likert scale assertions used to capture climate perception at different scales of psychological distance (temporal, spatial, social, and hypothetical).

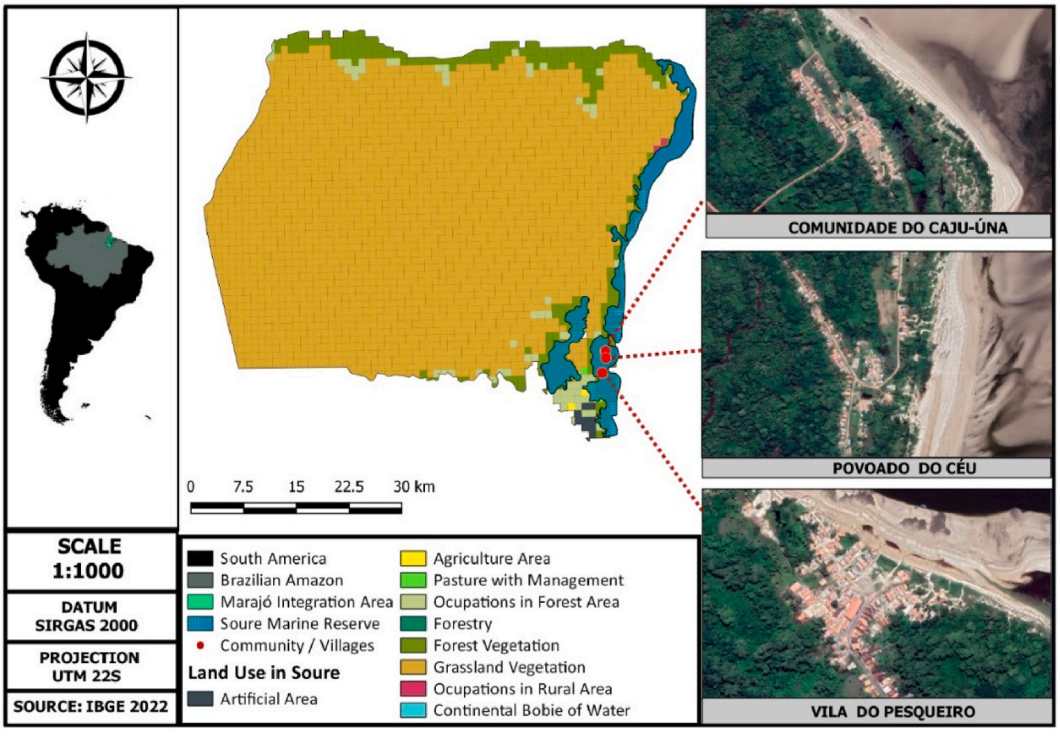

Fig. 1. Location of the communities within the Marine Extractive Reserve of Soure (Source: Assis et al. [6]).

2. Methodology

2.1. Characterization of the study area and the regional way of life

The Soure Marine Extractive Reserve is a federal Conservation Unit (CU) with a territorial extension of 29,578.36 ha. It is located on the eastern coast of the Marajo Island, the largest riverine island in the world, and the Amazon Basin estuary, where the Amazon River flows into the Atlantic Ocean from the west and the Tocantins River from the east [36]. Three communities are settled within the limits of this CU: Vila de Pesqueiro (7 km from Soure), Comunidade do Caju-Úna (18 km), and Povoado do Céu (23 km) [37].

The 249 extractivist families [38] are settled in natural and anthropogenic environments with vegetation composed of restinga areas [39], mangrove forests, dry and flooded fields, and tesos, which originated during the occupation of the island by pre-Columbian populations [40]. They survive off fishery resources (e.g. fish, crab, shrimp, and seafood in general), non-timber forest resources (natural oils and fruit), small animal husbandry (chickens, ducks, and pigs), crafts, natural products, and tourism-related activities [37]. During the "defeso", the period of the year when it is strictly forbidden by law to hunt, fish, or collect any resources from nature, the families benefit from Federal Government aid payments [38].

The capture of the uçá crab by arming (using a hook and iron), fishing with "rabiola" on the beaches, and the implementation of beaconing in streams to protect fishery resources stand out as traditional practices of using natural resources [41]. The productive chain the of andiroba and "do bicho" oil production, led by women, and the manufacture of handicrafts, especially marajoara pottery, are also among the use of natural resources that takes place in the region, reinforcing and valuing cultural identity [42].

2.2. Design of the questionnaire

We designed the questionnaire adapting the five-category scale developed by Ref. [43] to assess people's perception of climate change (Appendix I). The questions were organized within the following blocks: **I.** Socioeconomic (community, gender, age, education, occupation, distance from the community, and time lived in the community); **II**. Causes and beliefs concerning climate change (the extent to which people believe in this phenomenon and attribute it to human and/or natural causes); **III**. Individual or collective threat of climate change (the extent to which people perceive climate change threats as individual and/or collective); **IV**. Timing of climate change (as occurring soon or in the distant future) and **V**. Spatial or geographical distance of the climate changes (consequences of climate change as occurring nearby or far away). All questions were constructed in an affirmative form, within a 5-point Likert scale [44], to capture the level of agreement of the community members regarding the questions raised in our study.

2.3. Selecting informants and data collection

For data collection we selected informants who lived in one of the communities within the area delimited by the Marine Extractive Reserve of Soure and were 18 years old or older. The sample used in our study was the same used in the study conducted by Assis et al. [6], has a confidence level of 93%, which is acceptable for studies with human populations [45]. This quantitative reflects the sampling effort that corresponds to 44.98% of the population of these communities, considering the 249 families counted in the last government survey [46]. Considering a sampling, 112 interviews were conducted, of which 46 in the Vila do Pesqueiro, 31 in the Caju-Úna

Table 1
Socioeconomic data of respondents in Resexmar Soure.

Gender	Nº	%
Male	56	50.00
Female	56	50.00
Age		
18 to 20	8	7.14
21 to 40	26	23.21
41 to 60	42	37.50
61 or more	36	32.14
Education level		
Incomplete elementary school	60	53.57
Complete elementary school	7	6.25
Incomplete high school	10	8.92
Full high school	28	25.00
Complete higher education	7	6.25
Length of residence		
1 to 10	14	12.50
11 to 20	20	17.86
21 to 40	21	18.75
41 or more	57	50.89
Household size		
1 to 3	58	51.79
4 to 6	44	39.29
7 or more	10	8.93

community, and 35 in the Povoado do Céu (Table 1). The data were collected between march and April 2021 by applying questionnaires to the selected informants. All the participants agreed to response the form and signed the Term of Free and Informed Consent (TFIC).

2.4. Data analysis

To quantify the level of agreement of the community members with the statements, a scale was developed (following Assis et al. [47]) categorizing the level of agreement into scores. We considered 2 as the baseline value (minimum score) and 10 as the threshold value (maximum score) (Table 2).

To the statistical analysis, the linear mixed models were used to evaluate the influence of gender, age, education level, occupation, and location for each statement, in each block of questions separately. We built a global model with all the predictor variables to better understand the response variable. Then we selected the most parsimonious models from the set of all possible additive models with predictor variables using the Akaike Information Criterion (AIC) [48]. All models with ΔAIC lower than 2 were considered equally parsimonious [49]. When more than one model was selected, we calculated the mean model parameters and unconditional standard errors using the model.avg(.) function from the MuMIn package (Appendix II). All analyses were performed in the R environment [50] and the linear mixed effects models were performed using the lme4 package [51].

3. Results

The communities studied have knowledge concerning climate change and understand that this phenomenon has both natural and anthropic causes, which can threaten their well-being and local permanence. Such knowledge was evidenced by the high levels of agreement (Intercept) with the statements in all categories of analysis (Table 3).

In the statement block "Causes of Climate Change" we noticed that the community members have a level of agreement ranging from high (7.01) to very high (8.22), because they believe that this phenomenon is caused by both natural and anthropic factors. The results show that the older the interviewee the lower is the perception that climate change is a result of human actions in nature, and a combination of natural and anthropic factors. For older people, climate change is not happening at all. Those who live in the Povoado do Céu community, the one furthest from the urban center, also presented a reduced perception of the role of human beings in the climate change scenario.

In the "Individual or collective threat of climate change" group, the level of agreement of respondents concerning the risks that this phenomenon represents in the individual (to oneself), family, local (community), and regional (Resexmar Soure) categories ranged from high (7.43) to very high (8.54). Age was also negatively related to the perceptions for this block of statements, once the older the respondent the lower the belief that climate change threatens them, their family, their community, and/or the Soure Extractive Marine Reserve. The level of agreement of the interviewees in the block "Climate Change Timing", varied from high (7.12) to very high (8.31), which shows that the community members believe that the effects of climate changes are already being experienced by the communities and that it will continue for the next 5, 10, 15, 20, and 30 years.

> We observed a relationship between the distance of the communities and the agreement with the continuation of climate change, indicating that the people who live in the Caju-Una and Povoado do Céu communities, the most distant from the urban centers, were the ones who least believed in the continuation of climate change for the next 5, 10, and 20 years. Residence time was positively related to the continuation of these changes, indicating that those who live longer in their community have a greater belief in the occurrence of this event over the next 5 and 10 years.

In the "Spatial or Geographic Distance from Climate Change" block, respondents believed that climate change poses real threats to people at all geographical scales (8.67–9.27). In addition, the level of agreement of those who believe that climate change presents no threat at any spatial scale is lower (4.84–6.30).

The level of agreement of the interviewees with the impacts of climate change on the global and regional scales is positively related to education. Also, the interviewees that live in the more distant communities (Povoado do Céu and Caju-Úna communities) state that these changes do not present threats at any scale.

Table 2
– Categories of agreement levels (Adapted from ASSIS et al., 2020a).

Frequency category	Score
No agreement	2.0
Low agreement	2.1 a 4.0
Agree	4.1 a 6.0
High agreement	6.1 a 8.0
Very high agreement	8.1 a 10.0

Table 3
Perception of climate change of the population of the Marine Extractive Reserve of Soure based on the level of agreement with the statements and the associations with the socioeconomic and demographic variables.

	1. Causes of Climate Change						
Statements	Intercept with 95% confidence interval	Gender	Age	Education level	Occupation	Distance	Residence time
1.1 Climate change is being caused by human action in nature	8.27 (7.71–8.83)	0.055	**−0.77***	0.32	−0.10	−0.41	−0.04
1.2 Climate change is happening by the combination of natural factors and human action	6.97 (6.32–7.62)	−0.25	**−0.96***	0.50	−0.46	**−0.65***	**0.54***
1.3 Climate change is not happening	3.28 (2.76–3.80)	−0.17	0.43	**−0.55***	−0.38	0.24	**−0.85*****
2. Individual or Collective Threat of Climate Change							
2.1 For you individually	7.61(7.05–8.17)	0.23	**−0.84****	0.38	0.32	0.28	0.38
2.2 For your family	7.87 (7.33–8.41)	0.01	**−0.97****	0.05		0.01	0.01
2.3 For your community	8.23 (7.67–8.79)	0.01	**−1.75*****	0.28	0.26	−0.47	−0.23
2.4 For Resexmar Soure	8.40 (7.67–8.79)	0.13	**−0.90****	0.26	0.03	−0.43°	−0.16
3. Climate Change Timming							
3.1 We are already experiencing the effects	7.94 (7.33–8.55)	−0.04	0.08	0.15	0.08	−0.21	0.59
3.2 Five (5) years from now	7.55 (6.95–8.15)	−0.08	−0.30	0.25	**0.78***	**−0.61***	**0.78***
3.3 Ten (10) years from now	7.68 (7.09–8.27)	0.10	−0.57	0.25	**0.70***	**−0.75****	**0.56** *
3.4 Fifteen (15) years from now	7.52 (6.92–8.12)	−0.08	−0.26	0.24	**0.83***	−0.56°	0.46
3.5 Twenty (20) years from now	7.44 (7.67–8.79)	−0.19	−0.26	0.09	**0.78***	**−0.61***	0.41
3.6 Thirty (30) years from now	7.39 (6.78–8.00)	−0.05	−0.01	0.01	**0.82***	−0.44	0.14
3.7 We will never feel the effects	2.62 (2.27–2.97)	**−0.40***	0.04	0.21	−0.19	−0.05	0.26
4. Spatial or Geographic Distance of Climate Change							
4.1 The impacts of climate change are felt worldwide (global)	8.93 (8.46–9.40)	0.31	0.14	**0.61***	−0.09	−0.39	−0.09
4.2 The impacts of climate change are felt in all regions of Brazil (regional)	9.00 (8.55–9.45)	0.14	−0.05	**0.56***	−0.09	**−0.47***	−0.16
4.3 The impacts of climate change are felt in Marajó	9.22 (8.83–9.61)	0.12	−0.38	0.40°	−0.02	−0.28	0.03
4.4 The impacts of climate change can already be experienced here in the community	9.24 (8.86–9.62)	0.22	0.27	0.27	−0.25	−0.33°	0.08
4.5 Climate change presents no threat on any scale	5.57 (4.84–6.30)	0.38	0.29	−0.01	−0.14	**1.91*****	−0.09

Significance levels: *** (0–0.001); * (0.001–0.01); * (0.01–0.05).
Intercept: baseline value of the level of agreement for the analyzed statements

4. Discussion and conclusion

Local perceptions in the Soure Marine Extractive Reserve showed that community members agree that climate change is already happening. Their perceptions cover spectrums such as causes (combination of natural and anthropogenic factors), duration (it will last a long time), and the fact that climate change is a threat to the lives and livelihoods of residents. These perceptions reveal patterns shaped by socioeconomic and demographic factors and indicate that younger people have more accurate perceptions of climate change than those who are older and live in more distant communities, who agree less with the existence, consequences, and prolongation of climate change.

This more consistent perception of younger people can be understood by analyzing the local historical context, once the basic education institutions were implemented in the communities along with the creation of the Soure Marine Extractive Reserve in 2001 [25]. From this recent milestone, local residents (the youngest) had better opportunities to access information. Therefore, we believe that the educational background of the younger population is the best explanation for their better understanding of climate change, given that studies show that people who have a higher level of education have a more sensitive perception of climate change [2,52]. We also highlight that electricity came to the communities along with the schools through the Federal Government Program Light for All [53], and from this achievement the access to information among the new generation became popular through television, radio, and the internet. This milestone in the communities also explains the high perception among the younger generation, as predicted by studies showing that access to information increases awareness of the occurrence of climate change [54,55].

Older people living in communities further from the city tend to disagree more with climate changes, its causes, and its negative consequences. Similar results have been reported by Refs. [56–58]. In this study, the factors causing the low perception may be explained by the long time that the elderly members of the community lived in isolation. They settled in the territory and had minimal contact with other regions and consequently little access to sources of information [25].

We understand that the background of the older community members contributed to their settlement in the region, culminating in the construction of a local view of a world with little degradation. In general, people who are older, live further away and are less educated, are also more skeptical towards climate change. However, when it comes to personal threats, they show more concern,

agreeing that they do experience the negative consequences of this phenomenon. Such thinking reinforces that these people are unable to scale the impacts of climate change beyond themselves and their home community. This result indicates that older respondents present perceptions with a short spatial or geographical range, because their perception of the phenomenon is more sensitive when analyzing the existence and the local effect of this phenomenon. As regional and global scales are considered, the understanding of the phenomenon becomes more abstract [59,60].

According to the hypothesis of future projections, people have an average capacity for thinking about the future that does not exceed 10 years, and it is more difficult to construct a mental timeline that exceeds this limit [61]. This is due to the short social constructs, which are based on the 4-year election cycles and 5 to 20-year time frames used in community planning [62]. However, we have noticed that the results do not follow this pattern, once community members declare that climate change is occurring and will continue over the next 30 years. We believe that communication between the management organization and communities, driven by the challenge of combining the empirical knowledge of the population with scientific knowledge to share information regarding the future sustainability of this Conservation Unit [25], have contributed to these perceptions. Therefore, the knowledge shown by the high levels of agreement in the statements of this category of analysis, coherent or not with the currently observed patterns of weather conditions, comes mainly from the traditional knowledge developed from the close relationship that the communities have established with nature. Such knowledge has enabled a deep understanding of the dynamics and functioning of local ecosystems, since the high environmental perceptions in the Soure Marine Extractive Reserve are anchored in traditional knowledge [47,63].

Our results show that the degree of uncertainty concerning the future occurrence of changes associated with climate change does not increase over time, although this is often the case in studies that assess the psychological distance of climate change [59,64]. There is greater agreement that climate change will continue for the next 5 and 10 years among the people who live longer in the communities, revealing that their degree of agreement with the continuation of this phenomenon is linked to their expectation of the future: the older they are, the more limited their ability to think beyond 10 years. Overall, our results show an unusual pattern of perceptions, as events are expected to become more abstract with increasing geographic scales [8,65]. However, the high level of agreement on the consequences of climate change at different scales reveals that community members are able to perceive this event at both near and distant psychological scales, except for older people and those living further from the main cities, who have a short spatial distance from climate change.

Studies reveal that despite being rare, the increase in scale does not make understanding climate change abstract [66,67]. Similar to the hypothesis that best explains the understanding of the temporal prolongation of climate change, we believe that the understanding of this phenomenon at different geographic scales is due to the traditional knowledge and the numerous environmental awareness actions carried out by ICMBio through projects aimed at environmental education and the sustainability of local ecosystems [68]. Studies based on the Levels of Construction Theory have shown that psychological distance shapes levels of perception about climate change. The studies indicate that the more distant one is in terms of geographic, temporal, personal, and uncertainty scales, the lower the agreement with its consequences and the willingness to act and/or participate in actions to address and mitigate its effects. However, the present study shows that, in general, perceptions are high in both the near and far psychological scales. As a limiting factor, we highlight the heterogeneous sample, which concentrates older respondents, people who have accumulated more experience, and consequently influences the homogeneity of the results. It is important to emphasize that this quantitative figure reflects the number of people willing to answer the forms during the period in which the study was conducted. In future research to understand climate change at different scales, we recommend that greater efforts be made to collect data from a more heterogeneous matrix.

The high level of understanding of the studied phenomenon is based on traditional knowledge, revealing a deep knowledge about the functioning and dynamics of local ecosystems [47]. The results presented here highlight the importance of the Resexmar Soure's management body, which developed awareness raising activities with the communities. Such activities enabled a more assertive view on climate change, as it enabled the dialogue of different views on the subject [63]. Such results are encouraging, and we consider that the preservation of this knowledge is an important and priority action, as it provides insights to design adaptation strategies to climate change [69], which threatens the region and especially the traditional communities of the Soure Marine Extractive Reserve.

Author contribution statement

Davison M. S. Assis: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper. Priscila S. Medeiros-Sarmento: Conceived and designed the experiments; Performed the experiments; Contributed analysis tools or data. Ana C. C. Tavares-Martins; Bruno S. Godoy: Analyzed and interpreted the data; Wrote the paper.

Ethical aspects

The proposal was submitted and approved by the Biodiversity Authorization and Information System (SISBIO; process number 77218-1) and by the ethics committee, via Plataforma Brasil (opinion number 4.486.124).

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e18392.

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