

Climate dialogues and adaptive management: interventions for an experiential learning space in Novo Airão (AM), Amazon Region

Diálogos climáticos e gestão adaptativa: intervenções para um espaço de aprendizado experiencial em Novo Airão (AM), na Amazônia

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ABSTRACT

Climate change intensifies extreme events in the Amazon Region, including droughts and floods, which affect its local socio-ecological systems and increase local challenges and uncertainties. Experiential learning is an assumption in adaptive management that seeks to address information gaps and contribute to adjustments in the management process in response to uncertainties, increasing the adaptive capacity of socio-ecological systems. This paper presents the results of an action research study that aimed to promote reflexive thinking and understand the experiential learning process under the climate challenges in the Amazon Region. The study conducted participatory workshops with

public administration actors, private sector actors, scholars, and civil society in the municipality of Novo Airão, located in the Amazonas state (AM). We employed dialogical approaches and knowledge-building during the participatory workshops, integrating local, technical, and scientific knowledge. The oriented interaction among actors and the use of these methodological tools allowed us to identify risk areas and vulnerabilities and propose actions from a local perspective. This process indicated that spaces for dialogue strengthen the development of contextualised responses, and it highlights adaptive management as a strategy for addressing climate uncertainties.

Keywords: Adaptive Management. Experiential Learning. Socio-ecological Systems. Urban Amazon. Extreme Climate Events. Action Research.

RESUMO

As mudanças climáticas intensificam eventos extremos na Amazônia com secas e cheias afetando seus sistemas socioecológicos locais e aumentando os desafios e as incertezas locais. O aprendizado experiencial é um pressuposto da gestão adaptativa que busca lidar com as lacunas de informação e contribuir para ajustes no processo de gestão ante as incertezas, a fim de aumentar a capacidade adaptativa de sistemas socioecológicos. Este artigo apresenta o estudo fruto de uma pesquisa-ação, que teve o objetivo de estimular reflexões e compreender o processo de aprendizado experiencial diante dos desafios climáticos na Amazônia por meio de oficinas participativas com atores da gestão pública, de segmentos privados, acadêmicos e da sociedade civil no município de Novo Airão, no estado do Amazonas (AM). Para esse fim, utilizaram-se técnicas metodológicas dialógicas e de construção de conhecimento durante as oficinas, que permitiram integrar saberes locais, técnicos e científicos. Os resultados mostram que, a partir da interação orientada entre os atores e uso dessas ferramentas metodológicas, foi possível identificar áreas de risco e vulnerabilidades, assim como elaborar propostas dirigidas para ação na perspectiva local. O processo percorrido mostra que espaços de diálogo fortalecem a construção de respostas contextualizadas, assim como evidencia a gestão adaptativa como abordagem para lidar com incertezas climáticas.

Palavras-chave: Gestão Adaptativa. Aprendizado Experiencial. Sistemas Socioecológicos. Amazônia Urbana. Eventos Climáticos Extremos. Pesquisa-ação.

1 INTRODUCTION

Climate change, one of the core planetary boundaries (Steffen *et al.*, 2015), tends to increase the frequency and magnitude of extreme climate events (IPCC, 2019), such as droughts, floods, urban flooding, and wildfires (IPCC, 2021). These events in the Amazon Region have been linked to regional hydrology, such as extreme river floods and droughts (Marengo *et al.*, 2013), landslides, and severe wildfires during drought periods. These events affect local socio-ecological systems by changing their dynamics.

Socio-ecological systems are complex adaptive systems with integrated social and ecological variables that co-evolve and generate outcomes over time and space under uncertainties (Biggs *et al.*, 2022; Folke *et al.*, 2005). Ecological variables influence social dynamics, and societal actions represent structural factors of ecosystem dynamics at local to global scales (Biggs; Schlüter; Schoon, 2015).

The effects of extreme climate events on local socio-ecological systems are linked to the interaction among the hazard, the event itself, and the social and ecological conditions of the system. These conditions can also be understood as the vulnerability aspects of the system to extreme climate events. In the climate change context, there are three vulnerability aspects: exposure (ecosystem conditions, anthropogenic pressure, and occurrence of extreme events); sensitivity (diseases, demographics, socioeconomic conditions); and adaptive capacity (social capital, institutions responsible for managing events, safety infrastructure) (IPCC, 2007; Menezes *et al.*, 2018).

In Brazilian Amazon cities, urban sanitation, infrastructure, socioeconomic conditions, cultural relationships, local climate-sensitive diseases, and socio-political capacity represent vulnerabilities in local systems to extreme climate events (Mansur *et al.*, 2016; Menezes *et al.*, 2018; Pinho; Marengo; Stafford-Smith, 2015). Small towns present the highest risk level for these events, especially due to the lack of strategic plans for territorial planning. This, in turn, contributes to the weakness of adaptive capacity in addressing these events (Pinho *et al.*, 2024).

This is the case of Novo Airão, located in the Amazonas state (AM), a small town with slightly more than 15,000 inhabitants (IBGE, 2023), situated on the right bank of the Negro River. Since 2000, extreme climate events have been increasing in the city, such as extreme river flooding and droughts, mass movements, and wildfires (S2iD, 2019). Its vulnerability aspects include changes in land use, low infrastructure, climate-sensitive diseases, insufficient risk management tools, and low socioeconomic and socio-political organisation indices (Ipea, 2016; Menezes *et al.*, 2018). This scenario requires new organisational models and reorganisation of institutional and social processes to address the complexity of this issue, which is intertwined with interdependent variables.

Adaptive management is an approach that, within its procedural and structural framework, enables us to address abrupt scenarios, unpredictabilities, and uncertainties (Folke *et al.*, 2005), reorganising their planning and management processes to maintain the adaptive capacity of the system (Moretto *et al.*, 2021). This reorganisation involves adjustments over time through structuring mechanisms, connecting actors, capturing new information, and building shared knowledge from past experiences and diverse sources of knowledge (Allen *et al.*, 2011; Folke *et al.*, 2005; Moretto *et al.*, 2021).

The experiential learning between parties and the diverse participation of actors should be part of this adaptive management process (Dietz; Ostrom; Stern, 2003), since they enable us to share and develop new insights to address the information gap and uncertainties (Allen *et al.*, 2011; Moretto *et al.*, 2021). The plural participation of active actors in the system increases the response options and promotes more coherent solutions to specific needs, such as acting in areas at risk of extreme climate events (Biggs *et al.*, 2012; Shi *et al.*, 2016). Therefore, creating spaces that enable actors to connect and learn from their past experiences can provide a stronger foundation in planning future actions.

Studies on complex adaptive systems, such as socio-ecological systems, have shifted researchers' focus towards how studies are conducted, moving from observation to intervention in the objects of analysis (Preiser *et al.*, 2018). They have included different actors in the research process, integrating local, technical, and scientific knowledge to support the co-production of knowledge and action-oriented practices (Biggs *et al.*, 2022). Thus, participatory methods have been recognised for their potential in developing hybrid knowledge, addressing complex questions, and bringing local actors closer to socio-political coordination (Giatti, 2019).

We conducted an action research study in Novo Airão to promote spaces for experiential learning and reflexive thinking—from a local perspective—on climate challenges related to extreme climate events in the local urban context. We conducted participatory workshops with key actors from various social segments, using detailed dialogue techniques in our methodological approach. This study is structured as follows: Section 2 presents the theoretical background on experiential learning in adaptive management under climate challenges; Section 3 outlines the methodology; Section 4 reports and discusses the results of collectively constructed dialogues; and Section 5 concludes the study.

2 EXPERIENTIAL LEARNING IN ADAPTIVE MANAGEMENT

Experiential learning, adaptive capacity, and governance systems are assumptions for adaptive management (Moretto *et al.*, 2021). Studies conducted over the past two decades suggest that, based

on this approach, experiential learning involves understanding past events and enables actors to exchange and develop knowledge to guide the management process.

This assumption is significant due to the potential of various actors to learn from their experiences and develop skills and shared knowledge to address uncertainties, abrupt events (Folke *et al.*, 2005), information gaps, and changes in knowledge over time (Allen *et al.*, 2011; Dietz; Ostrom; Stern, 2003). This improves management and generates knowledge for management (Pahl-Wostl *et al.*, 2007). The procedure must be valid and supported by trust among parties, and its development will depend on the selection of actors in the governance arrangement (Moretto *et al.*, 2021; Pahl-Wostl *et al.*, 2007).

Different actors participating in experiential learning enable us to generate new information and develop interdisciplinary and transdisciplinary knowledge (Rist *et al.*, 2007). External, reliable information with accessible language is useful to adjust adaptive management (Dietz; Ostrom; Stern, 2003; Di Giulio; Martins; Lemos, 2016). Exchange between actors from social segments and different epistemological sources can increase the scope of knowledge, lead to more response options, and develop more consistent actions with local characteristics (Shi *et al.*, 2016). This context is similar to the post-normal science paradigm, since it proposes to increase the peer community to solve complex problems with uncertainty, such as environmental issues (Funtowicz; Ravetz, 1997).

Reflexive moments and skills in dealing with different perspectives contribute to learning among actors (Pahl-Wostl *et al.*, 2007). Dialogue among parties is inherent to the learning process, which affects the development of critical thinking and changing processes (Massimetti, 2022). Dialogue, as a relational process in a management context, must be structured with tools and explicit intentions previously presented to the actors (Drimie *et al.*, 2021). Thus, dialogue mediation among parties plays a crucial role in providing oriented experiential learning and using conflicts to enhance knowledge, rather than negatively affecting the process.

Experiential learning benefits all stages of the management process, such as development, implementation, and evaluation of actions addressing problems (Allen *et al.*, 2011). This approach allows us to adjust responses to new scenarios and changes that arise over time (Dietz; Ostrom; Stern, 2003). It provides flexibility to the management structure to readjust procedures. In addition, experiential learning strengthens social capital and collective action in management through the connectivity among actors and the sharing of knowledge and values (Pahl-Wostl *et al.*, 2007). For experiential learning to become a structuring element of the management process, tools and spaces need to be established.

Despite the theoretical advances, studies on the practical application of experiential learning in adaptive management to address climate change are still scarce. Therefore, the present study aimed to address this gap. It focused on urban contexts in the Brazilian Amazon Region to understand how experiential learning can improve local adaptive capacity to extreme climate events and how oriented dialogue can enable co-production of coherent responses.

3 METHODOLOGICAL APPROACH: LOCATION, PARTICIPANTS, AND WORKSHOPS OF THE ACTION RESEARCH

The action research was conducted between 2021 and 2023 in Novo Airão, in the Amazonas state, as indicated in Figure 1. The action research is an open, participatory, and flexible methodological approach. It enables dialogical processes and integrates demands identified during the study (Toledo; Jacobi; Santos, 2018), which should consider strategies for allowing social participation in the process of reflection, exchange, knowledge production, and problem solving (Toledo; Jacobi, 2013; Zanirato *et al.*, 2017). This method also enables us to design a planned action of social, educational, organisational, or

technical nature (Thiolent, 1992), shaping a research agenda for co-producing knowledge to influence the transformation of reality.



Figure 1 – Study region.

Source: The authors.

The participatory workshops with key actors were the main research mechanism. Participatory workshops are an action research strategy that enables us to apply specific techniques to social integration, exchange, and collaborative knowledge building in the research process (Zanirato *et al.*, 2017). In a cross-cutting manner, we adopted principles of problematisation by identifying generative topics and their reflection, based on the pedagogy of praxis and Paulo Freire, which enables a flow between action-reflection-action (Raymundo *et al.*, 2017). The first author of this study coordinated and conducted the participatory workshops.

Key actors, including “institutional actors” of the political, economic, cultural, and local social system, participated in the workshops, representing 13 organisations of the government, civil society, and market. Municipal government: 1. Environment Municipal Department; 2. Civil Defence Coordination; 3. Municipal Department of Infrastructure and Public Services; 4. Municipal Department of Industry, Trade, and Tourism. State government: 5. State Department of Economic Development, Science, Technology, and Innovation; 6. Amazonas’s Sustainable Development Agency. Federal government: 7. Chico Mendes Institute for Biodiversity Conservation. Civil society actors: 8. Rural workers’ trade union; 9. Amazon Entrepreneurship Centre; 10. Cooperative of Waste Pickers in Novo Airão; 11. Almerinda Malaquias Foundation. Local economic agents: 12. Flutuante dos Botos; 13. Reco Turismo.

We sent letters and folders via mobile messages and performed face-to-face conversations to mobilise and invite their participation, defending the importance of dialogue about a local and collective cause. Not all invited actors participated in the workshops, which is one of the challenges of action research (Toledo; Giatti, 2014), and imposed methodological limitations on the development of this study.

The Research Ethics Committee approved this study, CNS Resolution no. 510/2016. All participants signed the Informed Consent Form.

The participatory workshops (illustrated in Figure 2) occurred in two cycles, the first in 2021 and the second in 2023. In 2021, two-day sessions were held, lasting 4 hours each. We applied idea board techniques (developed by the researchers), interactive lectures (Althaus; Bagio, 2017), participatory mapping (Araújo; Anjos; Rocha Filho, 2017), and conversation circles (Moura; Lima, 2014). This dynamics is described in Section 4. The first cycle of workshops was recorded on video and included notes in the field diary and in the materials produced during the activities.



Figure 2 – Activities performed in the participatory workshops.

Source: Field file (2021).

In 2023, the second cycle of the workshop was held in a one-day session, lasting 5 hours. We also conducted participatory mapping and interactive lectures, but we applied another tool called the resolution round, which was based on the World Cafe dialogue method (Steier; Brown; Silva, 2015). Section 4 also presents this analysis. This workshop was only recorded in the field diary and materials produced during the activities.

Content Analysis (Bardin, 2011) was used to analyse and systematise the workshops, considering the materials written by the participants during activities. These records were coded into thematic categories. A critical narrative analysis, supported by reflective observation of the recorded videos and field diaries, was used to analyse the reflexive processes in the exchange of experiences and positions of the actors.

This study has limitations inherent to its participatory and interventionist nature in the considered context. Not all invited actors could participate in the workshops, as detailed in Section 4, restricting the diversity of perspectives and interactions. In addition, there was a notable gap between workshops because researchers faced difficulties in being in the field. This may have hindered a more continuous analysis of the learning process. Despite using multiple analytical methods for analysing workshops (content analysis, critical narrative analysis, and reflexive observation), no analytical framework is widely accepted for this type of research. However, the results highlight these limitations and indicate they do not invalidate our findings and praxis.

4 RESULTS AND DISCUSSION

The first cycle of workshops focused on a problematising perspective, recognising the effects of extreme climate events and climate change in the city. The second cycle of workshops aimed to solve the problems identified. It reviewed the discussions performed during the first cycle, in line with action research, and suggested strategic guidelines based on the adaptive management approach.

4.1 FIRST CYCLE OF WORKSHOPS: PROBLEMATISING FOR REFLECTION

The first cycle of workshops occurred in two-day sessions and involved 14 participants, representing 11 organisations. The Municipal Department of Infrastructure and Public Services, the Municipal Department of Industry, Commerce, and Tourism, and the Almerinda Malaquias Foundation (civil society organisation) did not attend, which affected the dialogue on more practical experiences related to these topics.

The group exercises in the workshops included conversation among participants in small groups and a plenary session. When divided into small groups, the actors themselves selected their partners for discussion. Table 1 describes the questions and general reflections that guided the activities, the methodological approach, and the goals of the first day.

Table 1 – Activities for the first day of the first cycle of workshops

<i>Activity</i>	<i>Methodological approach</i>	<i>Goal</i>
1 st What is climate change?	The participants were divided into small groups. They had 15 minutes for internal discussion, using notepads. Then, each group had 5 minutes to present the points discussed.	To promote discussion on the topic, an icebreaker.
2 nd Presentation on climate change and the Amazon Region.	Interactive lecture.	To present concepts and information related to scientific production; to integrate with the information discussed by the participants in the first activity.
3 rd What are the effects of climate change and extreme climate events?	The participants were divided into groups and used the idea board to associate effects with sectors. They had 15 minutes for internal discussion, and each group had 5 minutes to present the points discussed.	To highlight participants' recollections about past extreme climate events and experiences; to identify collectively the impacts of climate change and extreme climate events that the participants noticed.

Source: The authors.

The first activity introduced the topic to the participants and was an opportunity for them to relax. The second activity, "Presentation on climate change in the Amazon Region", integrated the participants' knowledge with scientific information, complementing the first activity and supporting the next ones. This activity showed that climate, as a long-term phenomenon, is not necessarily related to short-term variability. There were also other convergences in this activity, such as the causes of climate change. The impact of extreme climate events in the city was also presented, based on the national platform about extreme climate events known as the Integrated Disaster Information System (S2iD). This represents a dialogue between the technical and scientific knowledge and the practical experience.

The external and additional information presented through the interactive lecture contributed to filling knowledge gaps and raising awareness on the topic discussed (Tschakert; Dietrich, 2010). This resource has been applied as an active methodology to pedagogical practices to improve teaching and learning results (Althaus; Bagio, 2017). Thus, this workshop structure enabled participants to engage in the discussions by presenting their statements based on knowledge and questions about the topic.

The third activity, "What are the effects of climate change and extreme climate events? ", enabled us to explore the participants' memories of lived experiences. We applied the idea board technique by using poster boards placed over the workshop environment and dividing them into sectors, such as city and infrastructure, economy, healthcare, environment, education, and others. Therefore, participants discussed the guiding question in groups and placed the emerging ideas on the poster boards using sticky notes in different colours for each group.

Extreme river floods and droughts were the main effects indicated by the participants. The infrastructure sector identified issues such as the isolation of communities during extreme droughts. It flooded houses and schools located near rivers in the city and in the interior region during extreme floods. The economic sector highlighted impacts such as a drop in fishing production and product shortages. The healthcare sector addressed the spread of diseases and the difficulties in accessing healthcare services during the river droughts, which hinder navigation. The environmental sector highlighted the contamination of igarapés (Amazonian streams) and the extinction of animals. The educational sector presented changes in the school calendar due to logistical issues during extreme droughts. These points outline essential elements that should be addressed in adaptive responses to climate change.

Furthermore, during dialogues between groups, participants highlighted the vulnerabilities related to the lack of financial, technological, and infrastructure resources. These are challenging aspects to manage in this context. They are important elements for the adaptive capacity system when dealing with abrupt pressures, such as extreme climate events (Folke *et al.*, 2005; Smit *et al.*, 2001).

These activities enabled us to understand social and ecological aspects in an integrated manner, required to guide the adaptive management process (Dietz; Ostrom; Stern, 2003; Folke *et al.*, 2005). They supported the activities in the second cycle of workshops and showed the potential of participatory tools to understand local needs when facing climate change (Shi *et al.*, 2016; Tschakert; Dietrich, 2010).

Table 2 presents the next group exercises for the first cycle of workshops conducted on the second day. The fourth activity introduced key concepts of climate change and facilitated discussion, integrating them with elements of local reality through dialogue with participants.

In this activity, the participants associated the concept of mitigation with the possibility of increasing the use of bicycles as public transportation in Novo Airão. They also discussed the use of “marombas” in houses, which are wooden structures built on the floors to raise residences above the ground, as an adaptation to the flooding risks faced by houses located near rivers.

The fifth activity, “*Mapping risk areas in the urban area*”, used participatory mapping and selected key questions to problematise and define risk areas in the city. The key questions were: “Where do flooding points occur during heavy rains?”, “Where are the landslides located?”, “What are the flood locations during extreme flood periods?”, “Which places present difficulties during extreme drought periods?”

Table 2 – Activities of the second day of the first cycle of workshops

Activity	Methodological approach	Goal
4 th Presentation on the concepts of mitigation, adaptation, resilience, vulnerability, and climate risk	Interactive lecture	To present concepts and information on scientific production to function as shared tools; to integrate it with the participants’ knowledge.
5 th Mapping risk areas in the urban area	To perform participatory mapping using satellite images from the urban area; to conduct an open dialogue with all participants about the identified risk areas based on guiding questions.	To map risk areas in the urban area as guiding tools for future actions.
6 th Insights about the workshop	Conversation circle	To think about the workshop process, the knowledge presented, and the exchanges among participants; to understand what can influence everyday life.

Source: The authors.

The participatory mapping technique plays a crucial role in building unique cartographic features based on territorial characteristics and using local elements that would otherwise not be visualised (Araújo; Anjos; Rocha Filho, 2017). Therefore, we applied geoprocessing techniques in a geographic information system (GIS) environment, using the Quantum GIS program (QGIS.ORG, 2024), to perform it. We printed a high-resolution satellite image of the Novo Airão urban area (provided free of charge by WMS, BING, and Google) on an A3 sheet, circulated it among participants, and projected it on a screen to better visualise the areas that would or would not be marked.

We presented the guiding questions to participants once, and, after discussion and consensus among actors, we marked risk localities with dots, lines, and polygons. Figure 3 presents the participatory mapping. We can observe that the selected areas near river courses are related to extreme drought and flood events, while those surrounding forests are related to landslide risks.



Figure 3 – Participatory mapping results in 2021.

Source: The authors.

The last activity in this cycle, “*Insights about the workshop*”, was to think about the activities themselves through conversation circles. The participants emphasised the importance of the topic and the workshop to engage actors with the subject. They highlighted the interaction and knowledge exchange that the workshop provided. Participants mentioned the need for involvement of other actors—including residents of neighbourhoods identified as high-risk regions—and reported the importance of discussing this topic with children in schools.

Thus, the conversation circle enabled the exchange of experiences and the development of participants through reflexive processes. This occurred through the dialogical interaction and co-production of meaning among peers promoted by conversation circles (Moura; Lima, 2014).

The first cycle of workshops problematised the extreme climate events and the climate change scenario. It enabled us to identify issues and structural and sectoral gaps, and map risk areas in the city. We

highlight the definition of these problems, conducted in a collective, diverse, and participatory manner among the key actors.

4.2 SECOND CYCLE OF WORKSHOPS: THINKING THROUGH SOLUTIONS

The results of the first cycle guided the second cycle of workshops. In the 2023 cycle of workshops, activities aimed to validate data from the first cycle in a participatory manner, refine it, and promote structures for the collective construction of solutions to previously identified climate challenges. Table 3 presents the activities, the general methodological approach, and the goals.

Eleven people attended the second cycle, representing seven organisations. The Chico Mendes Institute for Biodiversity Conservation (an agency responsible for managing national conservation units), the state Department of Economic Development, Science, Technology, and Innovation, and some civil society organisations, among them the Rural Workers' Trade Union, the Amazon Entrepreneurship Centre, and the Cooperative of Waste Pickers in Novo Airão did not attend the workshops. The absence of these actors may have compromised the validation of data obtained in the first cycle of workshops, as well as the development of more diverse adaptive responses with specific characteristics.

To begin the activities of the second cycle, we applied the same approach as in 2021, starting with the guiding question, "What is climate change?" Our goal was to help participants relax and revisit the topics of debate, considering the time gap between the workshops. As there were new participants from the infrastructure and tourism departments, this activity also promoted exchange and conceptual alignment.

In this initial activity, participants continued pointing out the occurrence of extreme climate events, temperature increases, and their causes, such as deforestation, and added issues such as the use of large areas of land and high timber production. Unlike in the first cycle of workshops, participants did not associate climate change with "weather change," which may be related to the interactive lectures from previous meetings.

Table 3 – Activities of the second cycle of workshops

<i>Activity</i>	<i>Methodological approach</i>	<i>Objective</i>
1 st . What is climate change?	The participants were divided into small groups. They had 15 minutes for internal discussion, using notepads; and each group had 5 minutes to present the points discussed.	To allow the participants to relax and present the topic
2 nd . Exhibition on climate change, the Amazon, and the first data collected	Interactive lecture	To present the data from the first cycle of workshops; to discuss academic studies on the subject.
3 rd . Validation of the map of risk areas in the urban area	Use of the map created in 2021, with presentation of the satellite image with dots and polygons; open dialogue among all participants about the risk areas	To validate the mapping performed in the first cycle
4 th . Development of guidelines for the adaptive management of climate change	Resolution round with dynamics adapted from the World Cafe method; 10 minutes for dialogue on each axis	To develop guidelines for the adaptive management of extreme climate events

Source: The authors.

The second activity, “*Exhibition on climate change, the Amazon, and the first data collected,*” presented academic information on the subject and reviewed the results of the first cycle of workshops. Revisiting previously processed data and information enables reflection on what has already been learned and tested, leading to new understandings and changes in perspective (Tschakert; Dietrich, 2010).

Thus, the activity became a valuable moment of exchange and intervention by the participants, adding to the information presented. For example, when exposed to a satellite image showing the increase in the urban area of Novo Airão, participants commented on an urban policy in the municipality designed to collect property tax. This item on the agenda opened a debate that brought in other undisclosed information, such as the fact that the Amazonas Sanitation Company will begin water treatment and supply activities and will charge for the service.

Similarly, in this second activity, when data on the effects of extreme climate events were presented, participants commented on the 2021 flood, which mainly affected residents living near waterways. The context of uncertainty surrounding this event was evident in the participants’ comments, as the estimates provided by the municipal civil protection coordination—predicting that the level of the Negro River would rise by 15 cm per day—were contradicted by an actual rise of 30 cm in only 12 hours. This second activity highlights the importance of discussing the data presented with local actors, as this enriches the understanding that the process generates.

After this interactive lecture, the third activity of the meeting took place: “*Validation of the map of risk areas in the urban area.*” The participants addressed and discussed each area, leading to changes in the map created in 2021, which were consolidated into a new participatory map, illustrated in Figure 4. The red lines on the map correspond to the 2023 version. The yellow lines are the areas marked in the first cycle of workshops in 2021.

We removed area H (Santo Elias neighbourhood) from this new map, as participants reported that drainage works had been carried out, meaning it no longer presented a risk of flooding. However, this caused a moment of conflict among participants. Some emphasised the drainage works, while others argued that the service was ineffective, which led to the addition of area I as a new flood risk area point in the same neighbourhood (Santo Elias).

Also, new areas J and L were added. Area J refers to Porto do Padre, an alternative port to the city’s main port, which has been embargoed due to non-compliance with environmental legislation. Due to its location, it is exposed to extreme droughts in the watercourse, during which the use of the port becomes unfeasible. Area L (near the Peixe-boi residential complex) was added to the surrounding areas at risk of erosion, as participants considered that the entire area is compromised.

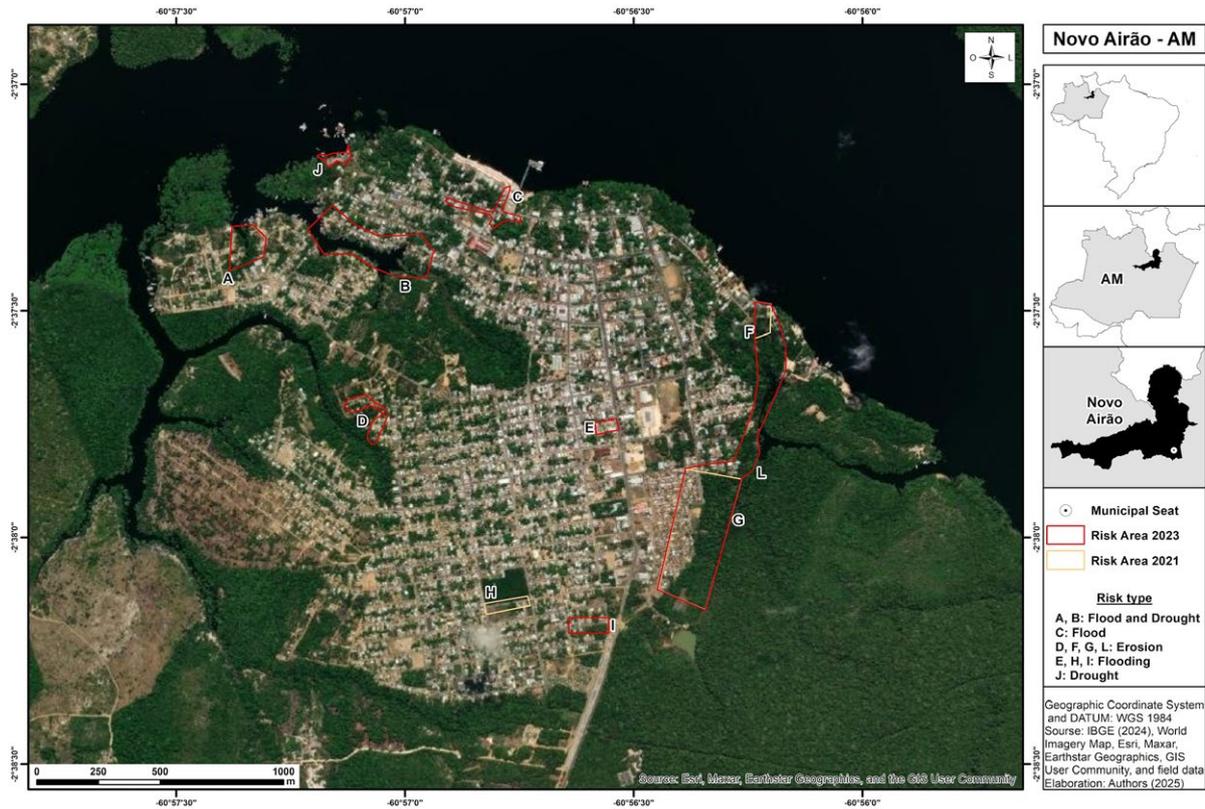


Figure 4 – Results of the participatory mapping in 2023.

Source: Authors.

The last activity of the second cycle of workshops drew on all the discussions held up to that point—on territory characteristics, memories of the effects of past extreme climate events, and the mapping of risk areas—to develop proposals organised around four priority themes that could guide future actions for adaptive management in the municipality. In the activity “*Development of guidelines for the adaptive management of climate change*,” these themes were presented to the participants and assessed to determine whether they were aligned with what participants considered strategic for the city. The four themes were: tourism, local economy, and income generation; planning and infrastructure; governance and institutional strengthening; and risk management.

To this end, we adapted the World Cafe method. Participants were divided into groups and took turns in 15-minute discussions on each of the themes. They had to discuss the proposed guideline, its justification, how it could be implemented, who would be responsible for it, and the deadline for its execution, recording their contributions on kraft paper sheets.

The largest number of proposed actions was in the planning and infrastructure theme, with the main proposals relating to the implementation of drainage works, sewage and treatment networks, solid waste management, and energy recovery from waste to address extreme climate events and climate change. For these actions, participants focused on fundraising and implementation plans, seeking inter-federative partnerships with universities and private-sector actors. They emphasised that the municipal Department for Infrastructure and Public Services should coordinate with the other relevant departments for implementation.

For the tourism, local economy, and income generation theme, proposals included projects for the historical and cultural promotion of the city, municipal land reform measures, incentives for independent community-based tourism, and the creation of an innovation incubator. These measures would be implemented through preliminary studies, stakeholder consultation, fairs, and the construction of a

facility equipped with technologies and led by a coordinator for the incubator. Several actors were mentioned as responsible for these actions, including municipal and state departments, the Institute of National Historic and Artistic Heritage, research institutions, and representatives of civil society and the tourism and local arts sectors.

In the area of governance and institutional strengthening, the proposals included creating mechanisms for dialogue between associations and authorities to foster participatory action planning, proposals aimed at institutional strengthening, adopting intersectoral software to improve administrative management, establishing municipal funds, and forming partnerships with neighbouring municipalities. These initiatives would be under the responsibility of municipal departments, city hall advisors, and representatives of civil society.

For the risk management theme, the proposals included establishing community civil defence centres to support participatory monitoring and developing a tool to enable participation in the preparation and implementation of contingency plans. These measures would primarily fall under the responsibility of civil defence, in collaboration with municipal and state departments and representatives of civil society.

In this activity, the development of proposals took longer than expected, which prevented its conclusion and was considered a limiting factor in the experiential learning process. Nevertheless, considering the nature of participatory research, the process is inherently subject to the participants' setbacks and to the live flow of the intervention itself.

In contrast, these workshop cycles have the potential to bring science, politics, and society together and strengthen public policies for adaptive management. This was possible with the participation of institutional and civil society representatives in a process extended to the municipality of Novo Airão, which employed a variety of strategies and techniques to foster dialogue and experiential learning on climate issues. Therefore, the action research process can be characterised as multilevel, expanded in scale, multi-instrumental, and functional concerning the emerging phenomenon (Giatti; Ribeiro; Toledo, 2014).

5 FINAL CONSIDERATIONS

The workshops were conceived as experiential learning spaces and guided by an adaptive management approach. Conducted through action research, with dialogue and interactive techniques, they fostered reflection, co-construction of knowledge, the development of innovative solutions, and shared understanding among participants. The workshop activities followed a logical sequence so that their outcomes could provide adjustments in management processes aimed at the system's adaptive capacity to deal with extreme climate events.

The workshop process shows that the iterative learning approach, in two cycles, enriched understanding through the refinement process, validating the role of heuristics in participatory work within complex systems. Likewise, the interactive lectures achieved their purpose of integrating knowledge and expanding information, which can contribute to local decision-making. Within the activities, this integration of knowledge fostered dialogue, participatory mapping, and solution-building during the resolution round. The latter two stand out as co-constructed outcomes from the workshops, with potential for socio-political application and guidance for actions in scenarios of uncertainty. Both can be further explored and adjusted for specific applications.

This study shows the importance of participatory spaces guided by experiential learning, with potential to address contextualised actions, in addition to increasing the capacity of local actors to adapt to climate change. Future research could analyse the medium- and long-term developments of research on interventions in the incidence of collective actions against climate change.

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