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Climate change and adaptive capacity in water management in the semi-arid region of Rio Grande do Norte

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Abstract: This paper investigates the incorporation of elements that enable adaptation processes to climate change in water resource management in the semiarid region of Rio Grande do Norte, Brazil. An exploratory and descriptive methodological approach of a qualitative nature was adopted, using bibliographic research, document analysis, and interviews with social and institutional actors involved in environmental and water management in the state. Based on these data, the strengths, opportunities, weaknesses, and threats (SWOT) of water management in the context of climate change adaptation were identified. The results indicate that despite advances in water resource management, adaptive capacity to address climate risks and impacts remains limited, primarily due to the lack of integration of these risks into the public agenda and strategic decision-making processes.

Keywords: Vulnerabilities; risks; adaptation; water resources; public policy.

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São Paulo. Vol. 28, 2025

Original Article

DOI: http://dx.doi.org/10.1590/1809-4422asoc01972vu28L4OA

Introduction

The Brazilian semiarid region, due to recurring drought episodes, advanced desertification processes, and water deficits associated with socioeconomic fragilities, is considered highly vulnerable to the risks posed by climate change (IPCC, 2007; Tavares; Arruda; Silva, 2019; Milhorance et al., 2019). The water deficit results from intense natural climatic variability, high temperatures, and irregular rainfall in both spatial and temporal terms, as well as from human activities related to resource exploitation and lack of environmental management (Simões et al., 2010).

In this context, climate change intensifies risks to water availability in the region, making its integration into Water Resources Management (WRM) essential. Furthermore, it demands improved water governance focused on reducing environmental, economic, and social vulnerabilities, thereby making it more adaptive to climate change. In light of this scenario, this study addresses the issue in the state of Rio Grande do Norte (RN), where the semiarid climate covers 93% of the territory, and recurrent droughts and dry spells significantly compromise water availability in much of the state.

Therefore, it is necessary to assess whether the existing institutional frameworks foster vulnerability reduction and incorporate climate adaptation principles. Accordingly, the objective of this paper is to investigate whether the WRM aimed at the semiarid region of RN includes elements that enable adaptation processes in the context of climate change.

From this perspective, the paper comprises, in addition to this introduction and the final considerations, three main sections. The first details the research methodology. The second discusses water resources, management, and climate change in the Brazilian semiarid context, emphasizing the importance of advancing climate adaptation. The third and final section presents an analysis and discussion on the possibilities and limits of adaptive capacity to climate change within WRM in the state of RN.

Methodology

This paper adopts an exploratory and descriptive approach with a qualitative character (Minayo; Sanches, 1993), conducting an instrumental case study on water resources management (WRM) in the semiarid region of Rio Grande do Norte (RN). The study is based on bibliographic review, secondary data analysis, and semi-structured interviews.

The bibliographic and documentary research enabled the review of key concepts and a comprehensive understanding of the studied area from environmental, social, economic, political, and institutional perspectives. The sources included scientific papers, books, official websites, reports, legislation, and plans from institutions such as the Water Management Institute of Rio Grande do Norte (IGARN), the State Secretariat for the Environment and Water Resources (SEMARH), the State Civil Defense (DC), and the Institute for Sustainable Development and the Environment (IDEMA), among others.

Semi-structured interviews were conducted with two main groups of key actors, totaling 14 interviews. The first group consisted of social actors, including seven researchers, graduate students, and professors affiliated with the Federal University of Rio Grande

do Norte (UFRN), the State University of Rio Grande do Norte (UERN), the Federal Institute of Education, Science and Technology of Rio Grande do Norte (IFRN), the Federal Rural University of the Semiarid (UFERSA), and the Brazilian Association of Sanitary and Environmental Engineering (ABES). All of them currently conduct or have previously conducted research and activities related to WRM in RN.

The second group was composed of institutional actors, including seven public agency representatives, technicians, and managers from SEMARH, IGARN, the Civil Defense, River Basin Committees, and IDEMA. These individuals play a central role in water management decision-making in the state. The interviews, averaging 45 minutes in length, were recorded with the participants' consent, formalized through the signing of a Free and Informed Consent Form (FICF).

The interviews, together with the other research instruments, provided the data and insights used to analyze climate adaptation capacity based on six dimensions proposed by Martins and Ferreira (2010) and Fritzsche et al. (2014): knowledge, technologies, institutions, financial resources, risk management, and social participation. These dimensions were selected due to their comprehensiveness in evaluating key factors that influence a system's ability to respond to the risks and impacts of climate change.

The SWOT matrix (Strengths, Weaknesses, Opportunities, and Threats), known in Portuguese as FOFA (Forças, Oportunidades, Fraquezas e Ameaças) (Araújo; Schwamborn, 2013), was applied as a structured analytical tool to assess WRM. This tool allows for the identification of strengths to be enhanced, weaknesses to be addressed, opportunities to be leveraged, and threats to be mitigated (Hofritcher, 2017). Moreover, it contributes to the formulation of more effective strategies for climate adaptation.

This approach enabled a detailed analysis of each dimension of climate adaptive capacity previously described. This methodology is widely used in the fields of urban and regional studies as well as in institutional planning and management, as shown in the study by Kummer and Silveira (2016). It facilitates the identification of gaps and potential solutions, relevant aspects for the interdisciplinary scope of this study.

Water resources, management, and climate change in the brazilian semiarid: the emergence of climate adaptation

The Brazilian semiarid region encompasses municipalities from all nine states of the Northeast, in addition to parts of Minas Gerais and Espírito Santo. According to the new resolution of the Deliberative Council of SUDENE (2021), the area comprises 1,477 municipalities (SUDENE, 2024).

This region is predominantly characterized by prolonged drought periods and high temperatures, factors that lead to high evaporation rates in its hydrographic basins and, consequently, reduced water availability, generating significant socioeconomic challenges (Santos et al., 2010). Beyond adverse climatic conditions, intense environmental degradation, driven primarily by intensive and predatory agricultural and livestock activities, has led to soil and vegetation exhaustion, further exacerbating impacts on water resource

availability and quality (Sales, 2002).

Historically, the region has experienced cyclical drought periods, occurring on average every 18 to 20 years per century (Marengo et al., 2017). However, it was only after the "Great Drought" of 1877-1879, which caused mass deaths and migration, that the State began to intervene, officially recognizing drought as a public issue (Travassos; Souza; Silva, 2013). Government actions focused on the construction of reservoirs, dams, irrigation canals, railways, and artesian wells (Silva, 2018). Nevertheless, these actions were insufficient to reduce drought impacts and social inequalities, as they preserved existing power structures and restricted access to water for the poorest populations.

Since the 2000s, public policies and the dissemination of social technologies have contributed to improving access to water for human consumption, animal hydration, and food production, especially in vulnerable communities (Dias et al., 2023; Santos et al., 2023). Notable initiatives include the implementation of plate cisterns, provision of credit and insurance, and technical assistance for rural populations. Despite progress, these initiatives remain insufficient to ensure water security, particularly during prolonged droughts such as the 2012–2017 event, the most severe in the past 100 years (Lima; Magalhães, 2018).

In this study, water security is understood as the guarantee of supply for essential human needs, economic production, and the preservation of aquatic ecosystems. In other words, it must be aligned with human well-being, socioeconomic development, and the reduction of inequalities, especially benefiting the most vulnerable populations (Melo; Johnsson, 2018).

In Brazil, water resources management (WRM) has improved significantly since the enactment of Law No. 9.433 of January 8, 1997, which established the National Water Resources Policy (PNRH) and defined the legal and administrative structure of the National Water Resources Management System (SINGREH) (Brasil, 1997). This legislation was a milestone, introducing a decentralized and participatory model that integrates the federal and state governments within a national system. It promoted advancements in water governance by establishing mechanisms for planning, monitoring, and regulating the use of water resources, thereby strengthening water security in the country.

However, in light of climate change risks, it is expected that there will be changes in the frequency, intensity, scope, and duration of extreme events, resulting in unprecedented impacts across various systems, particularly water resources, with adverse consequences for populations (Veyret, 2013; Brasil, 2017).

In this context, the Brazilian semiarid is identified as a high-risk area, highly vulnerable to future climate change (PBMC, 2013; Marengo et al., 2017). This highlights the urgent need to adopt new analytical perspectives and rethink current strategies, as emerging risks and challenges demand a more robust and adaptive approach. Adaptation refers to a system's capacity to adjust its characteristics or behavior to better address existing vulnerabilities (Brooks, 2003; Lindoso, 2018). In the context of climate change, it relates to the process of adjusting natural and human systems in response to climatic conditions (IPCC, 2014).

In this regard, Lemos (2016) argues that adaptive capacity is essential to achieving water security in a climate change context. Ambrosio et al. (2024) add that "the need to build adaptive capacity in the face of low water availability adds another layer of complexity to water security" (p. 4.555).

Strengthening adaptive capacity is crucial for risk management and effective responses to climate change impacts, enabling more efficient allocation of financial, social, and political resources (Eakin; Lemos, 2006). The climate adaptation literature highlights several key determinants of this process. For instance, Huitema et al. (2009) emphasize four core elements: polycentric governance, public participation, experimentation, and bioregional approaches. Pagan and Crase (2004) stress that continuous learning and institutional evolution are vital to integrating adaptive processes into water management. Complementarily, Geldof (1994) argues that WRM's adaptive capacity depends on factors such as effective communication, evaluation mechanisms, complexity management, and acceptance of subjectivity and uncertainty.

Uncertainties must not prevent the adoption of adaptation measures. In the case of no-regret measures, institutional strengthening, urban planning, environmental conservation, poverty reduction, and the provision of essential basic services are examples of necessary actions that contribute to adaptation (Denton et al., 2014). For WRM, implementing no-regret adaptation strategies involves adopting flexible structures capable of adjusting to high levels of uncertainty regarding future water availability. It is not necessary to know whether the temperature will increase by precisely 2°C or 3°C, but it is essential to recognize that any rise will compromise water security (Cysne, 2012).

Nevertheless, recent research indicates that many states and municipalities still lack a robust structure to cope with natural climate variability and do not possess sufficient adaptive capacity to deal with the impacts of climate change (Dias; Pessoa; Teixeira, 2023; Santos; Pessoa, 2025).

Possibilities and limits of adaptive capacity to climate change in WRM in Rio Grande do Norte

Water resources management in the state of Rio Grande do Norte (RN) was institutionalized through State Law No. 6.908 of July 1, 1996, which established the State Water Resources Policy (PERH) and the Integrated Water Resources Management System (SIGERH) (Rio Grande do Norte, 1996). This system was regulated by Decree No. 13.284 of March 22, 1997, which defined its organizational structure, including the State Secretariat for Water Resources (SERHID), the State Water Resources Council (CONERH), the State Environmental Council (CONEMA), and the River Basin Committees (Rio Grande do Norte, 1997a). The state law established the main management instruments, such as the State Water Resources Plan, the State Water Resources Fund (FUNERH), water use permits, licensing of hydraulic works, and water use charges. On January 31, 2007, the SEMARH was created under Complementary Law No. 163/1999 (Rio Grande do Norte, 1999), becoming responsible for coordinating the state's water and environmental policies.

The technical and operational capacity of WRM was reinforced with the creation of IGARN in 2002, through State Law No. 8.086, with the mission of regulating and supervising water resource use (Rio Grande do Norte, 2002). Given the natural limitations on water availability and the constraints in managing its distribution, which are further aggravated by climate change risks, more efficient solutions are needed to enable adaptation to climate impacts. In this context, climate adaptation refers to the capacity for response, adequacy, or adjustment of socio-environmental systems to the impacts of climate change (Adger, 2003; Klein et al., 2005; Pelling, 2011). It is from this perspective that we analyze climate adaptive capacity, based on the dimensions outlined in the methodology section.

Regarding the knowledge dimension, it is essential to have a robust database with information on climate, hydrology, and biotic and abiotic environmental factors, as well as an up-to-date register of users and demands. These should be systematized and made accessible via Geographic Information Systems (GIS), and readily available to decision-makers and the broader public (Brasil, 2018). An updated and comprehensive data platform enables proper risk management in the water sector.

However, the Water Resources Information System (SIRH) still presents limitations. Despite the existence of several online platforms with data on rainfall, reservoir volumes, and water quality, there is no integrated system that consolidates this information efficiently. In RN, planning still relies heavily on historical hydrological series. Yet, a key consideration for climate adaptation is that past hydrological behavior may not reflect future scenarios (Bates et al., 2008). This raises a crucial question: how can WRM be conducted in the face of climate change risks and their high degree of uncertainty (Brasil, 2016)? On this point, Beck (1998) emphasizes that scientific and technological advancement does not guarantee full prediction and control of risks, which, once identified, tend to be irreversible.

The State Water Resources Plan was first developed in 1999 and remained unrevised until 2019, when a public consultation process for its update began. In March 2022, the new plan was officially launched (Rio Grande do Norte, 2022), representing an opportunity to strengthen WRM, improve regulatory instruments, and implement water use charges, in line with the principles and guidelines of state legislation. The plan is the primary instrument with systematized data to support WRM.

Nonetheless, deficiencies were identified in monitoring, data systematization, short- and medium-term forecasting, and in the identification and spatialization of potential climate change impacts across the territory. The available knowledge base meets some short-term needs but does not offer a comprehensive outlook on whether there will be sufficient water to meet future demands or cope with extreme climatic events.

The technology dimension (Table 1) is also crucial to WRM, encompassing both information technologies that support knowledge production and infrastructure technologies. Technological use is a major ally in the search for rapid and effective solutions. However, such technologies must be aligned with sustainability principles, ensuring that they do not increase risks but instead mitigate human impacts on the environment (Kern;

Alber, 2008).

Technologies should aim to improve efficiency across different water uses, enhancing capture, storage, and reduction of rainwater loss. A wide range of technologies, methods, and practices already exist and can be replicated as long as they are simple, sustainable, and context-appropriate. Interviewees emphasized the importance of infrastructure, noting that although RN has an extensive network for water capture, storage, and distribution, it is still insufficient to ensure water security during severe droughts, as experienced in recent years.

Additionally, interviewees pointed to the need to revitalize some components of the supply system, as many are damaged. For example, some dams are at risk of failure, and many pipelines suffer from leaks and significant water loss. For interviewees, technological investments should prioritize quantitative and qualitative monitoring, infrastructure improvements, and environmental conservation.

Table 1 - Analysis of the "Knowledge and Technologies" dimensions

KNOWLEDGE		
Internal Factors	**Strengths**	**Weaknesses**
	• Hydrological, geological, pedological, and other data to support the creation of action plans. • Monitoring of rainfall patterns, reservoir levels, and river flows. • Communication and information dissemination through official websites, IGARN Itinerant, events, radio and TV, and river basin committees. • ANA provides strong support in monitoring and data availability. • Research fellows from diverse fields.	• No hydroclimatological modeling of river basins simulating climate change scenarios. • No groundwater or reservoir water quality monitoring. • Lack of agility and comprehensive coverage in user registration. • Limited interaction between academia and public authorities.
External Factors	**Opportunities**	**Threats**
	• Systematization of data from other agencies. • Continuous training on climate change. • Participatory diagnostics in river basins.	• Lack of financial resources. • Inadequate adaptation of monitoring technologies. • Failure to consider climate change risks. • Managers skeptical about climate threats. • Short-term vision.
	Positive	**Negative**

TECHNOLOGIES		
Internal Factors	**Strengths**	**Weaknesses**
	• Availability of water infrastructure (reservoirs, dams, wells, adductor systems) for collection and distribution across the territory. • Diffuse alternative systems (cisterns, underground dams, desalination units).	• Lack of more sophisticated equipment for quantitative and qualitative reservoir monitoring and aerial imagery capture. • Lack of technologies for sustainable management of soil, water, vegetation, and other resources. • Lack of maintenance of water supply infrastructure.
External Factors	**Opportunities**	**Threats**
	• Investment in low- and high-cost technologies for water treatment and reuse. • Technologies for depollution and recovery of water sources; protection of springs and riverbanks, etc. • Modern technologies to prevent water waste.	• Extreme climate events directly affecting water supply. • Deteriorated supply systems at risk of collapse. • Context-inappropriate technologies.
	Positive	**Negative**

Source: Authors' elaboration (2020).

Another aspect analyzed is institutional capacity (Table 2), understood here as the mix of social forms, including conventions, rules, organizations, and organizational systems (Miller, 2011). In WRM, institutional arrangements involve the entire SIGERH structure, including agencies, legislation, and actors, that enable the implementation of PERH instruments through integrated and coordinated actions. Institutional adaptive capacity, in this context, refers to the ability to respond to new problems with sufficient robustness to ensure water security under climate change risks (Dias; Pessoa; Teixeira, 2023).

Institutional adaptive capacity depends on the integration of climate risks into governance and decision-making processes. For effective adaptation strategies, climate change must become a political priority across all sectors, fostering skills for reflection, evaluation, and response to these risks.

In Rio Grande do Norte, the creation of a commission to draft a State Climate Change Policy marks an initial step, but significant institutional gaps remain, such as the lack of implementation of PERH instruments. Governments play a central role in shaping norms and governance mechanisms to address climate challenges at different scales (Giddens, 2010; Ferreira et al., 2011).

Financial constraints are among the main barriers to climate adaptive capacity, directly impacting WRM (Table 2). Despite SEMARH's administrative and financial autonomy, the FUNERH lacks sufficient capital to ensure the financial sustainability of water management actions. The regulation of water use charges, mandated by Decree No. 33.286/2023, represents a potential strategy to strengthen sectoral investments. However, effective implementation remains pending, with more significant progress observed in the Piancó-Piranhas-Açu River Basin (Rio Grande do Norte, 2023).

Table 2 - Analysis of the "Institutions and Financial Resources" dimensions

INSTITUTIONS		
Internal Factors	**Strengths**	**Weaknesses**
	• Specific agencies and legislation for WRM. • A state council and three river basin committees are established and active. • Committee working on drafting the State Policy to combat climate change effects, starting March 2020; until then, no specific legislation existed..	• Weaknesses in implementing PERH instruments. • Most staff are appointed positions or temporary research fellows. • Weaknesses in monitoring water users in river basins.
External Factors	**Opportunities**	**Threats**
	• Integration of climate change risks into WRM. • Civil service exams to hire permanent staff. • Participation in cooperation networks. • Partnerships between national and municipal levels.	• Discontinuity of policies and actions with changes in government. • Loss of key personnel. • Lack of interaction between governance levels. • Short-term planning.
	Positive	**Negative**

FINANCIAL RESOURCES		
Internal Factors	**Strengths**	**Weaknesses**
	• Progestão[1] funds for administrative activities, agency equipment, staff hiring, etc. • Federal government financial support for infrastructure projects.	• Charging for water use is in the process of being implemented in the state, with greater progress in the Piancó--Piranhas-Açu Basin. There is no charge for the licensing of hydraulic works. • Federal transfers occur mainly when the state declares an emergency, especially due to drought.
External Factors	**Opportunities**	**Threats**
	• Enforce water use charges and implement basin plans. • Seek private sector partnerships. • Integration with other sectors.	• Extreme climate events. • Increased water demand. • Lack of planning.
	Positive	**Negative**

Source: Authors' elaboration (2020).

As climate change intensifies the risks of natural disasters, risk management becomes a central component of adaptive capacity (Table 3). The increased frequency and intensity of extreme events (Zwiers et al., 2013) are not solely the result of climatic variations but also stem from structural vulnerabilities. Therefore, effective management must incorporate qualitative shifts, research on future scenarios, resilient infrastructure, and the identification of critical vulnerability points (Nunes, 2009; Brasil, 2016).

In Rio Grande do Norte, recurrent droughts cause major economic losses, especially in agriculture and fisheries, while floods, whether sudden or gradual, generate immediate impacts. Since 2011, the state has operated a Civil Protection and Defense Coordination Office (COPDEC) for emergency prevention and response. Nonetheless, the office faces challenges such as insufficient technical personnel.

Interviewees noted that the state prioritizes drought management over intense rainfall events, whose impacts, such as floods and structural damage, are more immediate. Dam safety also raises concerns, as many reservoirs, especially private ones, are structurally compromised, and IGARN's monitoring remains deficient.

To improve risk management, it is essential to strengthen technical-scientific research and promote dialogue between civil society and public authorities (Di Giulio et

1 - The PROGESTÃO program constitutes the consolidation of the "National Pact for Water Management" and is guided by the concept of payment for environmental services, in which the National Water Agency (ANA) provides financial disbursements linked to the achievement of planning and management targets within the scope of the Integrated Water Resources Management System (SIGRH).

al., 2013). Climate adaptive capacity also depends on social participation mechanisms (Table 3), which are crucial for debating, assessing, and planning public policies. Both the National Water Resources Policy (PNRH) and the National Water Resources Management System (SINGREH) advocate for participatory water management, with river basin committees playing a deliberative role.

Dialogue among government entities, sectoral committees, civil society, and research institutions is fundamental to WRM and climate adaptation (Di Giulio et al., 2013; Romero-Lankao & Hardoy, 2015; Sathler; Paiva; Baptista, 2019). In RN, the CONEMA, CONERH, and the river basin committees of Apodi/Mossoró, Piancó-Piranhas-Açu, Ceará-Mirim, and Potengi are the main forums for social participation, in addition to recurring events and forums addressing the topic. While there is notable engagement, interviewees pointed out the need to enhance representativeness and active involvement from various sectors.

Climate adaptation in WRM requires a favorable environment for social participation, supported by government, private sector, research institutions, and universities (Bulkeley & Newell, 2023).

Table 3 - Analysis of the "Risk Management and Social Participation" dimensions

RISK MANAGEMENT		
	Strengths	**Weaknesses**
Internal Factors	• 2017 Emergency Water Security Plan, with structural and non-structural measures to respond to prolonged droughts. • IGARN monitors 120 dams in the state to identify weaknesses. • State Civil Defense Council for decision-making in risk management. • CEMADEN monitors and issues early warnings of potential natural disasters to state civil defense agencies.	• Limited systematization of information on hydroclimatological risks. • No comprehensive risk and vulnerability maps for the entire state. • No risk management plans for dams, wildfires, among others. • Flaws in dam monitoring; many, especially private ones, have structural damage. • Lack of public guidance on disaster response. • Insufficient technical staff in the state civil defense agency; most municipalities lack a structured civil defense body.
	Opportunities	**Threats**
External Factors	• Community engagement in risk studies and actions.	• Failure to consider climate change risks. • Absence of dedicated risk management funds.
	Positive	**Negative**

SOCIAL PARTICIPATION		
Internal Factors	**Strengths**	**Weaknesses**
	• Established councils and committees. • CBHPA includes climate change discussions in its agenda. • Discussion forums among committees. • Updated state water resources plan with public participation. • The terms of reference for contracting the BHRAM Plan have been signed, but its implementation has not yet been made feasible.	• Only CBHPPA has an established basin plan. • Gaps in the effectiveness of social participation.
External Factors	**Opportunities**	**Threats**
	• Communication and mobilization of committee actions. • Promotion of environmental education in basin municipalities. • Participation in cooperation networks.	• Lack of mobilization for attending committee meetings. • Failure to include climate change debates in participatory bodies.
	Positive	**Negative**

Source: Authors' elaboration (2020).

In the context of WRM in the Brazilian semiarid region, it is possible to observe that, over time, effective drought response mechanisms have been developed, particularly through advances in the "living with the semiarid" approach. Nonetheless, coping with the natural variability and extremes of the semiarid climate remains a major challenge. Thus, a first step toward climate adaptation would be to address existing problems more robustly, thereby increasing management capacity to deal with more extreme events potentially intensified by climate change (Hallegatte, 2009; Brasil, 2016). However, as Burton (2010) points out, climate change adaptation involves new risks, greater complexity, and heightened uncertainty.

In terms of infrastructure development for expanding water supply and distribution in the state, it is essential to highlight major projects in their final stages of implementation, such as the São Francisco River Transposition Project and the Hydrosocial Project of the Oiticica Dam in the Seridó region. These projects aim to create integrated solutions: the Oiticica Dam will receive water from the São Francisco River via the Piancó-Piranhas-Açu River, and a series of facilities, such as canals and pipelines, will be built to distribute water to municipalities.

However, as in other northeastern states of Brazil, most responses to water scarcity in RN are centered on expanding water supply, particularly through medium- and large-

scale projects like dams, adductor systems, and canals. Meanwhile, other crucial strategies are often neglected, such as education for the rational use of water and environmental protection of water sources, especially considering the lack of sanitation services and the degradation of riparian forests, among other issues. As Puga (2018) aptly warns, water should not be treated merely as a commodity that can be transported from one place to another or as an inexhaustible resource whose supply can always be increased by searching for water farther away.

It is also vital to emphasize the fundamental role of municipalities in WRM and in supporting adaptive capacity. Although water is a federal and state resource, managed by laws and instruments established at those levels, municipal governments play a crucial role, especially in environmental conservation and safeguarding water quality within their territories. Moreover, municipalities are key to reducing the vulnerabilities of systems exposed to climate threats, as discussed throughout this paper.

In this regard, there is an evident need to foster integration between sectoral policies, at the federal, state, and municipal levels, particularly in the areas of territorial planning, urban development, waste management, public health, environmental protection, infrastructure, science, and technology. These policy domains are all critically important to ensure both water security and climate adaptation. Universities have been actively producing knowledge and show willingness to collaborate with governments. Social and institutional actors acknowledge climate risks, and the existing political-institutional frameworks provide favorable conditions for discussing and acting upon this issue. However, for progress to be made, climate change must gain visibility and priority in the public policy agenda (Dias; Pessoa; Teixeira, 2023).

In RN, the ongoing development of a State Climate Change Policy presents an opportunity to incorporate climate risks into various sectors. It is essential to formulate a sector-specific climate adaptation plan for water resources, in order to consolidate and expand current efforts while establishing clear guidelines for climate adaptation.

Conclusões

The analysis of the results discussed reveals that the state-level water resources management system in Rio Grande do Norte lacks the adaptive capacity necessary to address the risks posed by climate change. These risks are not yet incorporated into the public agenda, and the current management framework exhibits limitations that prevent the reduction of vulnerabilities within water systems exposed to these threats.

Despite limitations in the technological, financial, knowledge, and risk management dimensions, the state's WRM system has made progress, particularly in expanding supply infrastructure and strengthening management structures. The SWOT analysis of the six dimensions of adaptive capacity identified both challenges and opportunities for achieving more effective management, pointing to a favorable environment for the development of adaptation mechanisms.

In the short term, it is necessary to adopt a flexible approach, adjusting systems

to handle uncertainty and the complexity of the issue, while reducing vulnerabilities and building robustness in the face of future climate risks. Simultaneously, long-term adaptation requires proactive and structured planning, treating uncertainties as part of a continuous learning process.

Climate adaptation demands strengthened institutions, technological and financial investments, and an effective risk management system. Decisions regarding adaptation measures involve financial costs, underscoring the importance of in-depth studies to highlight the urgency of investing in this agenda now, in order to avoid more severe impacts in the future.

This study aims to contribute to the field of water resources management and climate adaptation, while also offering relevant insights for society and public administration. For this reason, the public sector must actively pursue the incorporation of elements that enable climate adaptation processes within water resource management strategies.

Acknowledgments

This study was supported by the Coordination for the Improvement of Higher Education Personnel (CAPES) - financial code 001; the National Council for Scientific and Technological Development (CNPq), under Call CNPq/MCTI No. 23/2020 (Grant No. 441883/2020-6); and the Foundation for the Support and Promotion of Science, Technology, and Innovation of RN (FAPERN), under Call FAPERN/CAPES No. 13/2021.

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Submitted on: 28/12/2024
Accepted on: 06/05/2025
2025;28:e001972

Data Availability Statement:

The entire dataset supporting the results of this study has been published within the article itself.

AMBIENTE & SOCIEDADE 25 anos 25 años 25 years

SciELO

Mudanças climáticas e capacidade adaptativa na gestão hídrica do semiárido do Rio Grande do Norte

Eric Mateus Soares Dias
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Zoraide Souza Pessoa

São Paulo. Vol. 28, 2025
Artigo Original

Resumo: Este artigo investiga a incorporação de elementos que viabilizam processos de adaptação às mudanças climáticas na gestão de recursos hídricos no semiárido do estado brasileiro, Rio Grande do Norte (RN). Para isso, adotou-se uma abordagem metodológica exploratória e descritiva, de natureza qualitativa, utilizando pesquisa bibliográfica, análise de documentos e entrevistas com atores sociais e institucionais envolvidos na gestão ambiental e hídrica do estado como instrumentos de coleta de dados. A partir dessas informações, foram identificadas as forças, oportunidades, fraquezas e ameaças da gestão para a adaptação às mudanças climáticas. Os resultados indicam que, apesar dos avanços na gestão dos recursos hídricos, a capacidade adaptativa para enfrentar riscos e impactos climáticos permanece limitada, sobretudo devido à falta de internalização desses riscos na agenda pública e nas decisões estratégicas da gestão hídrica.

Palavras-chave: Vulnerabilidades; riscos; adaptação; recursos hídricos; políticas públicas.

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SciELO

Cambio climático y capacidad adaptativa en la gestión hídrica en la región semiárida de Rio Grande do Norte

Eric Mateus Soares Dias
Rylanneive Leonardo Pontes Teixeira
Zoraide Souza Pessoa

Resumen: Este artículo investiga la incorporación de elementos que facilitan los procesos de adaptación al cambio climático en la gestión de los recursos hídricos en la región semiárida de Rio Grande do Norte. Para eso, se adoptó un enfoque metodológico exploratorio y descriptivo, de naturaleza cualitativa, utilizando la investigación bibliográfica, el análisis de documentos, y las entrevistas con actores sociales e institucionales involucrados en la gestión ambiental y hídrica del estado como instrumentos de recopilación de datos. A partir de esta información, se identificaron las fortalezas, oportunidades, debilidades y amenazas de la gestión para la adaptación al cambio climático. Los resultados indican que, a pesar de los avances en la gestión de los recursos hídricos, la capacidad de adaptación para hacer frente a los riesgos e impactos climáticos sigue siendo limitada, sobre todo debido a la falta de internalización de estos riesgos en la agenda pública y en las decisiones estratégicas de la gestión hídrica.

Palabras-clave: Vulnerabilidades; riesgos; adaptación; recursos hídricos; políticas públicas.

São Paulo. Vol. 28, 2025

Artículo Original