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Original Articles

Climate adaptation and renewable energy: A systematic literature review

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Authors' notes

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Abstract

Objective: To analyze how scientific literature approaches renewable energy as adaptation strategies to climate change.

Methodology: A methodology with a qualitative approach was employed, using a systematic literature review as a methodological procedure and content analysis as a technique for processing the data collected.

Originality/Relevance: The systematic literature review study on the topic in question is crucial, as it made it possible to identify themes that require evidence in the scientific literature, helping, based on what has already been investigated and written on the topic, to guide future research.

Results: The results discussed indicate that, of the 42 papers analyzed, only 12 bring, in a more central way, renewable energies as strategic to face climate change. However, it is possible to conclude that this association still occurs, above all, from the perspective of mitigating Greenhouse Gas emissions, without understanding such energy sources as promoters of climate adaptation, promoting, among other results, the reduction of vulnerabilities and socio-environmental risks.

Social contributions to management: The paper makes it possible to see, for example, how climate adaptation capacities have been built, incorporating renewable energies as mitigation and, in particular, adaptation strategies.

Keywords: climate change, climate adaptive capacity, mitigation, energy transition, sustainability

Resumo

Adaptação climática e energias renováveis: Uma revisão sistemática da literatura

Objetivo: Analisar como a literatura científica aborda as energias renováveis enquanto estratégias de adaptação às mudanças climáticas.

Metodologia: Foi empregada uma metodologia com abordagem qualitativa, utilizando a revisão sistemática da literatura enquanto procedimento metodológico e a análise de conteúdo como técnica de tratamento dos dados coletados.

Originalidade/Relevância: O estudo de revisão sistemática da literatura sobre o tema em questão é crucial, pois possibilitou a identificação de temáticas que necessitam de evidência na literatura científica, auxiliando, a partir do que já foi investigado e escrito sobre o tema, na orientação para pesquisas futuras.

Resultados: Os resultados discutidos apontam que, dos 42 artigos analisados, somente 12 trazem, de forma mais central, as energias renováveis enquanto estratégicas para enfrentar as

mudanças climáticas. No entanto, é possível concluir que essa associação acontece ainda, sobretudo, numa perspectiva da mitigação das emissões de Gases do Efeito Estufa, sem compreender tais fontes de energia como promotoras de adaptação climática, fomentando, entre outros resultados, a redução de vulnerabilidades e riscos socioambientais.

Contribuições sociais/para a gestão: O artigo possibilita observar, por exemplo, como se vem construindo capacidades de adaptação climática, incorporando as energias renováveis enquanto estratégias de mitigação e, em especial, de adaptação.

Palavras-chave: mudanças climáticas, capacidade adaptativa climática, mitigação, transição energética, sustentabilidade

Resumen

Adaptación al clima y energías renovables: Una revisión sistemática de la literatura

Objetivo: Analizar cómo la literatura científica aborda las energías renovables como estrategias de adaptación al cambio climático.

Metodología: Se utilizó una metodología con enfoque cualitativo, utilizando como procedimiento metodológico la revisión sistemática de la literatura y como técnica de procesamiento de los datos recolectados el análisis de contenido.

Originalidad/Relevancia: El estudio de revisión sistemática de la literatura sobre el tema en cuestión es crucial, ya que permitió identificar temas que requieren evidencia en la literatura científica, ayudando, a partir de lo ya investigado y escrito sobre el tema, a proporcionar orientación para futuras investigaciones.

Resultados: Los resultados discutidos indican que, de los 42 artículos analizados, sólo 12 traen, de manera más central, las energías renovables como estratégicas para enfrentar el cambio climático. Sin embargo, es posible concluir que esta asociación todavía se da, sobre todo, desde la perspectiva de mitigar las emisiones de Gases de Efecto Invernadero, sin entender dichas fuentes de energía como promotoras de la adaptación climática, promoviendo, entre otros resultados, la reducción de vulnerabilidades y riesgos socio-ambientales.

Contribuciones sociales/de gestión: El artículo permite ver, por ejemplo, cómo se están construyendo capacidades de adaptación al clima, incorporando las energías renovables como estrategias de mitigación y, sobre todo, de adaptación.

Palabras clave: cambio climático, capacidad de adaptación al clima, mitigación, transición energética, sostenibilidad

The risks of climate change are becoming more and more realized, as pointed out by the assessment reports of the Intergovernmental Panel on Climate Change (IPCC). For example, in 2023, the IPCC's sixth assessment report reinforced anthropogenic interference on the increase in Greenhouse Gas (GHG) emissions, aggravating climate risks and impacts on systems across the planetary system (IPCC, 2023). In conceptual terms, climate change consists of a natural phenomenon of climate modification over the long term (UNFCCC, 1992), with a strong influence from anthropogenic action (IPCC, 2007).

These risks and impacts of climate change, mainly affecting the most vulnerable systems, signal what is called in contemporary times a "state of climate emergency," requiring the need and urgency of implementing national and international agendas in which they think in an integrated and collective way. An example of this is with the agendas related to the energy sector, considering that it is the main responsible for global GHG emissions, registering approximately 76% of emissions, especially carbon dioxide (CO_2), according to data from the World Resources Institute of Brazil (WRI BRASIL) (Friedrich et al., 2023).

Worldwide, energy production and consumption patterns continue still on fossil and non-renewable sources (such as oil and its derivatives), with more than 80% of the energy matrix coming from these sources (Alcoforado, 2019; International Energy Agency [IEA], 2023). This generates GHG emissions and, consequently, warms planet Earth with effects on the global climate system, changing it faster than usual.

The IPCC's sixth assessment report, in addition to bringing the challenges and obstacles to be faced by the increase in GHG emissions in the world, also proposes possible solutions, among others, to deal with climate risks after they have already happened. Therefore, one of these solutions is the search for an energy transition to a low-carbon economy based on renewable-based energy sources (such as hydro, wind, and solar), as they are energy sources with low CO_2 emissions – although highly impactful. As a result, the energy and electricity sector play an essential role in the perspective of mitigation through renewable energies.

In this sense, renewable energies can be seen as important examples of technologies for the energy transition worldwide (Tavares, 2020). This is because they refer to the energies generated from natural resources that come from non-fossil sources (Bjork et al., 2011) and that, as a final product, have a low capacity to emit GHG, especially CO_2. Thus, renewable energy sources play a crucial role in mitigating the emissions of these gases. Conceptually, mitigation, in the context of climate change, is understood as reducing or eliminating global GHG emissions process and carbon sequestration in ecosystems (Smith et al., 2008). From this perspective, these sources are considered strategic for tackling climate change, as indicated in studies such

as that of Niedertscheider et al. (2018).

On the other hand, these energies can (and should) also be thought of as climate adaptation strategies when discussed in the context of energy and electricity diversification of territories, as presented by Eyre et al. (2018), who understand this diversification as one of the ways to deal with global climate change. Climate adaptation is understood as a process of adjustments in a system aimed at anticipating possible and potential climate impacts at the local level based on climate projections, seeking to reduce vulnerabilities and socio-environmental risks associated with climate change (Pelling, 2011).

More specifically, renewable energies can be an important strategy from the point of view of adaptation, considering that their use can occur as a process of individual and collective behavioral change in society to reduce situations of vulnerability and socio-environmental risk related to the climate, such as lack of access to electricity. For example, wind energy can be used as a form of electricity production for populations in a context of water vulnerability to climate change due to the possibility of scarcity of rainfall regimes (Wang et al., 2014; Berga, 2016; Galbiatti-Silveira, 2018).

In the debate on climate change and renewable energies, this article is handy in theoretical-conceptual and analytical terms, as it attempts to contribute to a gap in the field of scientific literature on the subject, contributing to the understanding that renewable energy sources can be configured as resources with capacities to adapt to climate change. From this perspective, this study seeks to observe the hypothesis that the scientific literature commonly associates renewable energies with a perspective of mitigating GHG emissions, sideline, or even not considering such energy sources as a form of climate adaptation.

According to this contextualization, the objective of this article is to analyze how the scientific literature approaches renewable energies as strategies for adapting to climate change. For this, this analysis was anchored in a methodology with an exclusively qualitative approach, using a systematic literature review as a methodological procedure and content analysis as a technique for treating the collected data. From this perspective, this article is structured, in addition to this introduction and conclusions, in two topics: the first is the presentation of the research methodology, while the second is the analysis and discussion of the results obtained with the research.

Methodology

To meet the objective proposed in the introduction, the methodology used in this article follows the guidelines of a systematic literature review, understood as an observational and

analytical methodological perspective, in which it seeks to identify, systematize, report and critically analyze a given theme (De-la-Torre-Ugarte-Guanilo et al., 2011; Galvão & Pereira, 2014; Roever, 2017), corroborating with the existing scientific evidence or subsidizing the construction of new scientific knowledge. More specifically, the systematic review of the literature can be understood as a rigorous methodology with specific objectives, as pointed out:

> [...] Identify studies on a topic in question, applying explicit and systematized search methods; evaluate the quality and validity of these studies, as well as their applicability in the context where the changes will be implemented, to select the studies that will provide the EC and make their synthesis available, to facilitate their implementation in the PBE (3-4) (De-la-Torre-Ugarte-Guanilo et al., 2011, p. 1261).

These objectives need to be clear so that the researcher can respond or meet what he was proposing. A systematic literature review is a methodological resource with an original contribution, as it usually presents new results on a theme or a certain field of scientific knowledge (Galvão & Pereira, 2014). It is important to clarify that this systematic literature review does not aim to present and discuss essential aspects in the development of systematic literature reviews, such as some studies on the subject (Sampaio & Mancini, 2007; Galvão & Pereira, 2014; Galvão & Ricarte, 2020); but rather to identify a gap in the scientific literature regarding the approach to renewable energies as a strategy for adapting to climate change. Chart 01 systematizes the steps presented for the process of elaborating a systematic literature review, with application to the case of this research.

Chart 01

Steps for the elaboration of the systematic literature review in this research

Steps	Descriptors elements
01 Definition of the starting questions	How does the current scientific literature address renewable energies in the context of climate change adaptation? What specific gaps have not yet been addressed regarding adaptation to climate change in the context of renewable energies? What are the main perceptions and emerging trends in the scientific literature regarding the role of renewable energy as climate adaptation strategies? And how can these perceptions and trends influence future mitigation policies and practices and, above all, adaptation?
02 Search in literature	Selection of the database: scientific productions from the Scopus database (Elsevier) in the thematic areas of "Environmental Science," "Energy," and "Social Sciences." Search keywords: "renewable energy," "adaptation," and "mitigation." Delimitation for articles available for open access, with the publication stage completed. Publication period: 2018-2023 (search conducted on March 14, 2023).
03 Selection and evaluation	Deletion of duplicate articles (does not apply). Analysis and sorting of relevant articles: Are the articles within the established time limit? Do the articles bring the approach to adaptation to climate change in the context of the energy issue?
04 Analysis and synthesis	Coding of the selected articles, considering: Objective and methodological approach of the research.
05 Dissemination and use of the results	Synthesis and content analysis.

Source: Elaboration by the authors (2024)

It is important, initially, to define the starting question(s) in an objective, clear, and directive way (Sampaio & Mancini, 2007; Galvão & Ricarte, 2020). In the case of this systematic review, the starting questions are in the sense of understanding how the scientific literature approaches renewable energies as climate adaptation strategies. After this definition, a survey of peer-reviewed scientific articles indexed in Scopus was carried out from 2018 to March 2023, the date of access and filtering of the articles in the mentioned database. It is worth noting that the choice of Scopus was because it is one of the largest databases of scientific production in the world, developed by the company Elsevier and which presents a vision of world scientific research in various fields (social sciences, biology, climate sciences, arts, humanities, among others).

In order to search for scientific evidence, the survey of articles in the Scopus database

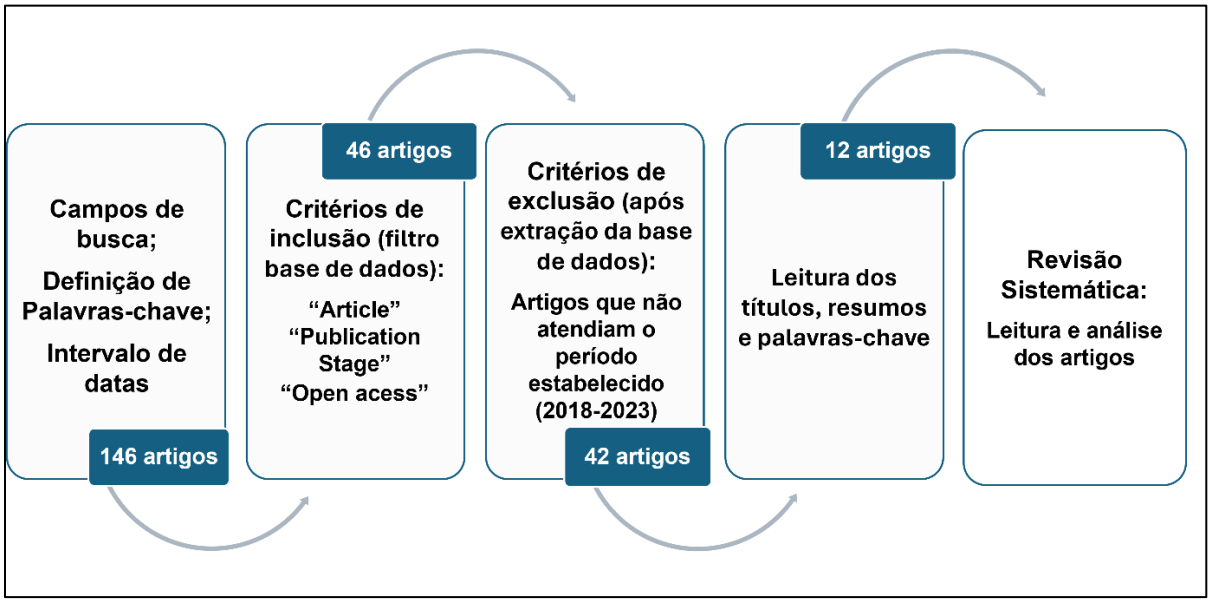
was because of the definition of search patterns: i. search fields "Article Title," "Abstract," and "Keywords"; ii. Keywords: "renewable energy," "adaptation," and "mitigation"; and iii. date range: from 2018 to 2023. It is important to mention that the search for keywords in English was due to enabling a greater reach of articles on the subject in the international scenario.

About the results returned by these search engines, 146 scientific articles were obtained. Subsequently, the following inclusion criteria were established: "Article," "Publication stage," and "Open access." From there, 46 documents were obtained, with the subsequent exclusion of four, as they were not in the established date range, leaving 42 documents. This exclusion criterion was defined because it seeks the most recent scientific articles published on the subject of this research.

After this process, the titles, abstracts, and keywords of the 42 articles were read, using the direct relationship between renewable energies and climate adaptation as a central selection criterion for the subsequent reading of the documents in their entirety. Thus, 12 articles were produced with this thematic approach, which went through a systematic literature review. Figure 01 systematizes the methodological design for the development of this systematic literature review study.

Figure 01

Methodological design of the systematic literature review in this research



Source: Elaboration by the authors (2024).

In developing the systematic literature review, content analysis was used, following the

perspective of Bardin (2011), as a technique for processing the data obtained, considering that content analysis is, as Prezenszky & Mello (2019, p. 1569) pointed out, a "path for the construction of critical reviews of scientific production in the humanities, more specifically in the systematic bibliographic review." To this end, the categories of analysis established were: "Climate change," "Climate projections," "Renewable energies," "Mitigation," "Adaptation," "Resilience," "Renewable energy sources adapted to drought extremes," and "Poverty and vulnerability." (Chart 02)

Chart 02

Research analysis categories

Analytics Category	Description
Climate change	Mention of climate change in the context of the search for energy transition, decarbonization, and sustainability.
Climate projections	Historical data integration, climate models, and emissions scenarios that contribute to the analysis of future climate change.
Renewable energies	Identification of renewable energies as mitigation and adaptation strategies in the context of climate change.
Mitigation	Alignment of renewable energies as measures to reduce or eliminate GHG emissions.
Adaptation	Orientation of renewable energies as strategies to reduce socio-environmental vulnerabilities and risks associated with climate change.
Resilience	Understanding renewable energies as resources that can increase the resilience of a territory's energy sector to climate change and variability.
Renewable energy sources adapted to drought extremes	Identification of renewable energy sources in a context of adaptation to drought extremes.
Poverty and vulnerability	Intersection between energy, poverty, and vulnerability in renewable energy production territories.

Source: Elaboration by the authors (2024).

These analytical categories, based on an open analysis grid (the categories are identified as the analysis material is being explored) (Vergara, 2005; Lukosevicius & Soares, 2016), were selected due to their ability to capture the data and information that are crucial for the analysis and discussion of the results in the topic in sequence.

Analysis and discussion of the results

The scientific literature on the subject of renewable energies, such as wind energy, has pointed to a series of negative impacts of these energies on territories and their communities

(Meireles et al., 2013; Hofstaetter, 2016; Felix, 2018; Costa et al., 2019). From this perspective, the socio-environmental impacts are the most diverse and multidimensional (Meireles, 2011; Hofstaetter, 2016), implying that they are not isolated impacts but already pressing characteristics of this productive activity type.

Among them, for example, in the case of the state of Rio Grande do Norte, in the Northeast macro-region of Brazil, are i. the segregation of communities; ii. the change in health conditions due to the disturbances caused by the noise of the wind farms (such as insomnia and depression); iii. changes in sociocultural dynamics, and changes local and regional economic; iv. de-characterization of the landscape and territorial geographical change; and v. decrease in animal production (Hofstaetter, 2016).

While renewable energies generate and intensify vulnerabilities and risks for populations and the environment, generating socio-environmental impacts, they are also a source of low CO_2 emission capacity, acting in the mitigation of GHG emissions. As a consequence of its performance in the face of the climate change scenario under a mitigative bias, renewable energies are thus crucial in achieving global decarbonization (Mathiesen et al., 2011; Mchenry, 2012; Ellabban et al., 2014; Warren, 2019; Passaro et al., 2020; Wang et al., 2021; Andreucci & Zografos, 2022). Decarbonization consists of a process of reducing GHG emissions, especially CO_2, generated from the burning of fossil fuels (Grubler, 2012; González, 2018; Oliveira et al., 2020).

Although renewable energies are seen as crucial energy sources for the mitigation of GHG emissions, especially CO_2, there is a need for discussion and reflection on such energy sources as climate adaptation strategies in a context in which the fields of science and public policies do not observe this dialogue in an integrated and synergistic way.

In this context, considering the methodology presented above, it is initially noted that Nkiaka and Lovett (2018), when addressing the integration of climate adaptation in sectoral public policies in Central Africa from a case study carried out in Cameroon, show that the country's government has made significant progress in terms of incorporating public policies or actions aligned with climate adaptation in the energy and forestry sectors, with little integration, on the other hand, in the agriculture and water resources sectors. In the case of the energy sector, for example, out of a total of 30 policy documents found, only five focused on the energy sector. Regarding adaptation to climate change, the focus given by the government of Cameroon in the energy sector is especially on the development and modernization of the energy matrix, with the main climate adaptation initiatives in this perspective being the use of renewable energies and the increase of energy efficiency in the country.

The incentive for the expansion and production of renewable energies is seen by Nkiaka and Lovett (2018) as a way to promote climate adaptation, given the possibility of changing a national energy base, in which it seeks to incorporate "new" forms of electricity generation through energy sources beyond fossil fuels, thus contributing to the processes of energy transition and global decarbonization.

From this perspective, the authors understand renewable energies as technological resources for climate adaptation because they understand that they can work as a way to increase the resilience of the country's energy sector to climate change and variability to the extent that they can (and usually succeeds) improve the conditions for adaptation of territories and populations to climate change. That is because renewable energies can be, for example, sources to "power early warning systems, telecommunications systems, health clinics and drinking water systems" (Ley, 2017, p. 187).

In this regard, it is worthy of note that, for example, in contexts of risk situations such as water shortages, other renewable energies, such as wind and solar, can function as sources of electricity generation for populations, making them not run out of electricity supply and, thus, harm their activities, such as cooking food or developing some work activity.

The government of Cameroon also has other initiatives to mitigate and adapt to climate change through the use of renewable energies, which concerns the consumption of biomass (another renewable-based energy source). In this case, the country has developed actions to distribute more fuel-efficient cooking stoves to local communities to reduce the number of trees cut down for firewood (Nkiaka & Lovett, 2018). These actions are part of a project financed by carbon revenues, with the participation of *CO2balance* and the African Centre for Renewable Energy and Sustainable Technology (ACREST), with impacts on adaptation by reducing poverty and protecting biodiversity and ecosystems but also to mitigation by contributing to the removal of GHGs (Nkiaka & Lovett, 2018). Such actions are, therefore, both mitigation and adaptation since they simultaneously enable the reduction of GHG emissions (mitigation) and reduce vulnerabilities and socio-environmental risks (adaptation).

In Garoua, the capital city of the northern region of Cameroon, for example, in 2022, the government launched its Sustainable Energy and Climate Action Plan (SEAP) (CoM SSA, 2022), which is a document focused on strategies and actions to combat climate change for the 2030 horizon, including concrete mitigation measures, adaptation and access to renewable energy (Palermo et al., 2019). However, even though it is a document aimed at access to "sustainable" energy and climate change from an integrated perspective, it is not very clear how renewable energies are or could be incorporated as climate adaptation strategies.

It is worth mentioning that, in line with Nkiaka and Lovett (2018), Speranza and Wills (2019) consider that renewable energies (whether from hydroelectric plants, wind turbines, or photovoltaic panels, for example) are important strategies for adapting to climate change, because, among other characteristics, they are an option for improving energy security and the stability of electricity supply in the territories.

Specifically in the case of poverty issues, Venema and Cisse (2004) consider that renewable energies assume a dual role in the face of climate change and global climate policy and that this duplicity can be explained from the dimensions of poverty and vulnerability. The aspects commonly associated with poverty are the lack of economic resources (such as income), access to essential services (such as education, housing, and health), and access to participation in decision-making processes.

Furthermore, poverty is intrinsically associated with vulnerability since it conditions an individual or social group to be vulnerable to situations of risk and possibly to adverse events, such as those related to the climate. Thus, energy is a way to reduce issues of poverty and vulnerability (Schaeffer et al., 2003), creating capacities to respond to socio-environmental problems, such as climate change. One of the ways to promote and implement this capacity and, consequently, reduce vulnerability is through renewable energies such as wind and solar, as these can replace renewable hydro energy sources in situations of stress (such as water scarcity), ensuring energy security but also non-renewable ones (such as fossil fuels).

Schwoerer et al. (2020), while contributing with their research to a better understanding of the food-energy nexus in rural communities in the Arctic and subarctic regions, point out that these communities still live in isolation in situations of vulnerability and dependent on fossil fuels for the harvest of wild foods, facing challenges related to climate adaptation not only from the perspective of incorporating the increase in energy costs but also of the environmental, social, and economic effects.

The authors understand that renewable energy is a climate adaptation measure, as communities, such as those residing in the Arctic and Subarctic, may be able to take advantage of local renewable sources of electricity generation by moving away from fossil fuels. For example, Wolfe and Scott (2010) state that, more recently, families in the regions have started to use *switching* technology, a system for operating more energy-efficient computer networks installed in several locations close to risks, replacing fixed networks.

Schwoerer et al. (2020) understand that this substitution consists of an adaptation strategy insofar as an adaptation it promotes in the context of change and variability climate. However, the authors, by concluding that the results of their study are crucial for the interface between

mitigation, energy, and food security, end up, to a certain extent, reinforcing the alignment that the scientific literature commonly makes between renewable energies and mitigation, sidelining adaptation and the idea that such energies are also a way to adapt to climate change.

Vara et al. (2020) highlight, based on scientific studies on climate projections, the need to design and implement public policies on climate change that address both mitigation and adaptation in contexts of high socio-environmental vulnerability, as is the case of the islands of the Mediterranean region. These projections point out, however, that the need for adaptation in the energy sector, especially renewables, is quite limited, given that, in general, they indicate scenarios with a decreasing trend in wind energy productivity, with significant decreases according to the RCP8.5 scenario (Vara et al., 2020)

By reinforcing that the integration of climate adaptation into public policies or energy initiatives, especially renewable-based, is still a gap and obstacle in contemporary times, it is understood, on the other hand, that such energies can also contribute to the processes of adaptation to climate change, acting to reduce vulnerabilities to socio-environmental risks. For example, the case of a water shortage makes it necessary to find other sources to produce electricity for the population.

In this context, assuming that the projections indicate that climatic and water conditions will increase the electricity demand, reduce transmission capacity, and limit energy production, without the planning for the expansion of electricity capacity not considering climate and water constraints, Miara et al. (2019, p. 14030) find, among other results, that wind and solar energy are technologies "less affected by warm air temperatures and require minimal amounts of water for operations compared to thermal energy technologies, which implies a lower vulnerability to climate and water constraints."

Thermal energy, depending on the source of its generation, can be considered a renewable-based energy. For example, if your raw material is sunlight, it consists of renewable energy. However, the important thing in this discussion is that renewable energies, such as wind and solar, are less vulnerable in the event of climatic and water limitations, such as rainfall extremes.

Furmankiewicz et al. (2021a), when analyzing the objectives, planned actions, and performance indicators in documents related to climate change and renewable energy defined by national and local rural stakeholders in the Poland region found that the Rural Development Program (RDP) 2014-2020 and the Local Development Strategies (LDS) gave little notoriety to local climate change and renewable energy actions. This scenario is common in other national territories, such as Brazil, when their climate and energy public policies present a little look at

local territories and their communities.

Educational actions for climate change mitigation and adaptation are part of 66% of the LDS, while investment in renewable energy was only 9% of these Strategies (Furmankiewicz et al., 2021a). On the other hand, more traditional objectives, such as support for local businesses and farmers, were placed as more relevant in these initiatives (Furmankiewicz et al., 2021a). Regarding the RDP 2014-2020, these authors note that there is a low political will of the actors linked to Poland's national rural development program to incorporate and implement the climate change and renewable energy objectives in its document through, for example, its principles and guidelines.

Another research with a locus also in Poland focused on the problem of fishing is a study developed by Furmankiewicz et al. (2021b), who discuss fishing in the region of Poland, analyzing public policies on fishing and local development. The results and discussions of the article indicate that it was possible to verify that the mitigation of climate impacts and the development of renewable energies did not figure prominently in the documents analyzed.

With this, the authors concluded, in suggestive terms, that both national policymakers and local *stakeholders* in Poland's fisheries regions had a low level of awareness of climate change, as well as their role in solving this problem. This aspect is in line with what was presented previously through the study by Furmankiewicz et al. (2021a). In general, in none of the studies led by Furmankiewicz (2021a,b), renewable energies, wind, and solar were placed as a measure with a crucial role in climate change adaptation processes.

Eitan (2021), when discussing renewable energies from the perspective of facing climate change from the political discourse in Israel, highlights that these energy sources can become technological resources as much for mitigating GHG emissions and adapting to climate change and its impacts. On this front approach to climate change, Eitan (2021, p. 2) points out that renewable energies play "a crucial role in climate change adaptation strategies because they can reduce the vulnerability of energy systems to extreme events."

When analyzing whether decision-makers responsible for Israeli renewable energy policy tend to focus on mitigation or adaptation strategies, Eitan (2021) finds that such national policymakers are more focused on promoting renewable energy as public policies or mitigation initiatives than on adaptation. Thus, even though Israel is not a major GHG emitter, it should be noted that its public policies on renewable energy have focused on mitigating these gases rather than on adapting to their climate impacts. In 2020, the country was responsible for 58,472 kilotons (kt) of CO_2 emissions, according to data from the World Bank (The Global Economy, 2020). For

Eitan (2021), greater visibility and even an important international role have been given to mitigation to the detriment of adaptation, corroborating what has been signaled by other studies (Obermaier; Rosa, 2013; Lindoso, 2013; Di Giulio et al., 2016; Rodrigues Filho et al., 2016; Teixeira et al., 2021).

The results found in the analysis by Yin et al. (2021), when developing a literature review based on the Q methodology for the case of regulatory planning in China regarding the perspective of mitigation and adaptation, highlight in the same sense as the findings of Eitan (2021). In other words, public policies aimed at renewable energies, when they bring the perspective of tackling climate change, still focus on mitigating GHG emissions and do little or even do not focus on adapting to climate impacts. This evidence can be seen in recent studies such as that of Teixeira (2023) investigating three states in the Northeast of Brazil that are high wind and solar energy producers. Yin et al. (2021) highlight that, among other mandatory indicators for regulatory planning, there is one referring to the "application of renewable energy technologies for the development of municipal infrastructure." which effectively helps in the mitigation of climate change, not associating it with climate change adaptation processes.

Di Battista et al. (2021) understand that, in a context of growing attention and awareness in society about climate change, driving the elaboration and implementation of local and national public policies to address climate problems, the planning of energy and environmental confers operational solidity to the concept of sustainable development, especially about issues involving energy. In this sense, the authors developed and validated a scientific methodology to review the Sustainable Energy Action Plans (SEAP) and the monitoring phase of the municipalities.

The results found by these authors show that the plans in question (as operational instruments of the municipalities for the integrated renewable energy planning, including, for example, the local production of renewable energy sources) represent a future step in the integration of territorial and environmental aspects in the municipal energy sector, especially, when they refer to climate adaptation, the reduction of vulnerabilities and risks of water scarcity, and land consumption. It is important to note, however, that wind and solar renewable energies are not integrated into the analysis of Di Battista et al. (2021) as measures to adapt to climate change, being placed, especially as important for the reduction of CO_2 emissions, as presented in the scientific literature in general. Some examples of studies that affirm this are those by Sims (2004), Bevan (2012), Niedertscheider et al. (2018), Tcvetkov (2021), and Teixeira and Pessoa (2022).

Even so, such as the study developed by Nkiaka and Lovett (2018), others can directly perceive the association between renewable energies, especially wind and solar, and climate

change, even from the point of view of adaptation. For example, Howells et al. (2021) assess for the context of Zimbabwe, an African country with a large part of its emissions mitigation centered on hydropower generation and other forms of electricity production that are vulnerable to climate change, the level of risk of its Nationally Determined Contribution (NDC) in a context of climate change, analyzing options to increase NDC resilience to ensure attaining the objectives set.

By using, as a methodological resource, the Open-Source Energy Modeling System (OSeMOSYS), Howells, et al. (2021) present two paths of adaptation to this climate vulnerability of the African country. The first of these is the implementation of coal, but the authors point out that, although it is a climate adaptation option that promotes resilience to the national electricity system, it is responsible for the intensification of GHG emissions in the national context. At the global level, fossil fuels, the group of energy sources to which coal belongs, were responsible for 36.8 billion tons of CO_2 in 2023, increasing by 1.1% compared to 2022 (ClimaInfo, 2023).

The other path is about the incentive for wind and solar expansion, using hydroelectric energy as a renewable resource to balance these new energy sources of electricity generation (Howells et al., 2021). However, for this path to be effective, there would be a need for complementary investments and changes to the rules of the energy market, allowing the achievement of the objectives of the NDC. The need for climate adaptation policies has arisen due to the continuous and effective occurrence of extreme weather events, but this has not been accompanied by financing and investments by national or local institutional structures. That makes governments continue to prioritize traditional non-renewable sources, such as coal, because, among other factors, they do not need to invest in new market structures. This aspect, as well as investment in support measures (such as coal storage), is corroborated by Howells et al. (2021)

In the last two articles analyzed in this systematic review, there is one by Andreucci and Zografos (2022) and the other by Faaij (2022). In the first article, the authors, through a literature review, developed a conceptual systematization based on Foucault's observations on biopolitics and racism, with a critical analysis of alterity as a "government technology" in the context of climate change. Renewable energies, considered "green" in the article, are presented from the perspective of mitigating GHG emissions, contributing to low CO_2 production. However, this approach to renewable energies is pointed out by a set of studies, as presented throughout this article.

In the second article, by Faaij (2022), the discussion on the use of biomass as a renewable-based energy source takes place from a constructive view of the perspectives and preconditions for sustainable bio-based economy options to mitigate and adapt to climate change.

In the analysis developed, it is not clear how biomass, as a renewable energy source, is configured or crucial for climate adaptation processes. In the same way that other renewable energy sources (wind and solar, for example) are mostly seen as mitigators of GHG emissions, the use of biomass is presented by Faaij (2022, p. 01) in his analysis as "one of the most important mitigation options to reduce GHG emissions, as highlighted by several IPCC reports and scenarios over the years [1–4], as well as the IEA [5], IRENA [6], etc.", as reinforced below in the conclusions.

Conclusions

The debates around climate change and renewable energies are themes of various fields of scientific knowledge production, such as Environmental Sociology and Energy Geographies, which interface with Urban and Regional Planning. In these fields, climate and energy issues are discussed from different perspectives, and one of them is the perspective of renewable energies as a way to mitigate GHG emissions, with the capacity to reduce or eliminate CO_2, contributing to the decarbonization of the global economy.

On the other hand, recent scientific studies also highlight the role that emerging renewable energies have in climate adaptation processes (Ley, 2017; Nkiaka& Lovett, 2018; Speranza & Wills, 2019), with the capacity to reduce vulnerabilities and socio-environmental risks imposed by climate change and its effects on systems. Nevertheless, it is a scientific interdisciplinary field that is still incipient in terms of studies.

This incipience is corroborated, for example, with the articles analyzed and discussed in the previous topic, and it is possible to perceive that the association between renewable energies and climate adaptation is still a gap in the scientific literature. The reason for this isthe scientific studies analyzed, in general, still do not perceive renewable energies as a strategy for adapting to climate change, prevailing as a technology aimed at mitigating GHG emissions.

As a result, it is possible to verify the hypothesis that the scientific literature on the subject associates renewable energies as strategies for mitigating GHG emissions, with little understanding that they are also a perspective of climate adaptation. In the meantime, the objective proposed in the introduction was achieved based on the results obtained with this study, observing how the scientific literature produced between 2018 and 2023 addresses renewable energies as strategies for adapting to climate change.

The systematic literature review developed in this article is particularly crucial in identifying topics that need evidence, such as renewable energy and climate change, with a focus on adaptation, helping, based on what has already been investigated and written about these topics, to guide future research. In future research, there is an analysis of how territories build climate

adaptation capacities, incorporating renewable energies as mitigation and, in particular, adaptation strategies. With this, it is possible to observe how this gap in the scientific literature is also effective in building and implementing climate and energy governance in an associated and integrated way.

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