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Editorial

Ignacy Sachs (1927-2023) – a sustainability pioneer

Marcel Bursztyn, Carlos Hiroo Saito and Patrícia Mesquita

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The idea of sustainable development owes much to professor Ignacy Sachs, who passed away in early August 2023. Sachs stood out as one of Maurice Strong's advisers, the Secretary General of the United Nations Conference on the Human Environment, held in 1972 in Stockholm (Sweden), for being a pioneer in considering the environmental variable as an inseparable attribute of the quest to development. During this event, the concept of eco-development was launched, which would serve as inspiration for the Our Common Future Report from 1987, which proposed the sustainable development concept. Coordinated by former Prime Minister of Norway Gro Harlem Brundtland, the document was the backbone of the United Nations Conference on Environment and Development, in 1992, in Rio de Janeiro. From then on, the debate on development had to consider the environmental issue.

Ignacy Sachs was a Polish economist who fled the Holocaust with his family when he was 12. In his autobiography (SACHS, 2007), he narrates the saga until his arrival on Brazilian soil, passing through several European countries. In Brazil, he studied economics, and at the end of the 1950s, he returned to Warsaw, where he worked, under the coordination of Michal Kalecki, at the School of Planning and Statistics, one of the cradles of the planning theory. His doctorate focused on development, based on his studying experience in New Delhi, India. Throughout his academic life, Sachs always evoked the relevance of comparative studies between Brazil and India, two countries that, in his view, should serve as a foundation for development strategies in third-world countries.

In Paris, he founded the Center for Research on Colonial and Contemporary Brazil – CRBC, at the School of Advanced Studies in the Social Sciences in the 1970s. Some important academic and political exponents of Brazilian politics that lived in exile during those times of military dictatorship had the chance to attend the weekly debates he organised. Leonel Brizola, Miguel Arraes, Celso Furtado and Fernando Henrique Cardoso are some of the participants.

Besides, many Brazilians were welcomed at the CRBC as students or researchers. The first to complete a doctorate under his guidance was Professor Cristovam Buarque. His experience inspired the creation of the Center for Sustainable Development – CDS at the University of Brasília, where he was dean.

Sachs had a strong presence in the post-dictatorship Brazilian intellectual and political landscape. He served as a political adviser, consultant and mainly as an academic reference. His ideas inspired the first master's and doctoral programs on environment and sustainability. The creation of the Graduate Program on Sustainable Development (master's and doctorate) at the University of Brasília and the Sustainability in Debate Journal can be linked to Sachs' actions that influenced our country.

His works are pillars of new studies and policies. When discussing the bioeconomy as a strategy for sustainable development in the Amazon, we cannot forget that Sachs had a pioneering and inspiring role when he proposed the notion of biomass-based civilisation (SACHS, 1993).

Sachs was also a pioneer in the debate on policy integration, avoiding the risks and setbacks of conflicts between sectoral policies. In the early 1980s, he coordinated a study for the United Nations University, in which he launched the Nexus concept around the interfaces between biofuel policies and food production. Currently, the Nexus approach is used in several analyses, especially when linked to water, energy, and food security, and, lately, socio-environmental security (COUTINHO *et al*., 2020).

Ignacy Sachs continues to inspire us and help us see the light at the end of the tunnel. With this in mind, we are delighted to announce that our journal has been listed as a Q3 journal in 2023 by the Scimago Journal and Country Rankings (https://www.scimagojr.com/journalsearch.php?q=21100824458&tip=sid&clean=0). Thus, nothing is more normal than honouring and dedicating this issue to Ignacy Sachs's memory.

Let's continue turning his dream into reality.

In this second issue of 2023, SiD publishes ten articles in the *Varia* section. First, Cerezini and Hanai discuss the challenges and guidelines for integrated water management in river basins. Next, Gonçalves *et al*. discuss the relationship between industry dependence on fossil fuels, oil disasters, and the characterisation of the social determination of health in vulnerable territories. Canova *et al*. investigate how climate change has threatened the livelihood and cultural dimensions of peri-urban communities in Central Amazonia, while Fardin *et al*. discuss the identification of extreme rainfall events and disasters triggered by rain in the city of Petrópolis-RJ.

Ribeiro highlights the possibilities for generating energy from biomass in the state of Minas Gerais. Silva *et al*., through a territorial focus, propose an approach to identify the determining factors for inserting mini and microsystems of distributed generation in the agricultural sector. Lobo and Pinto assess the level of road cyclability in the city of Belo Horizonte-MG based on an analysis of indicators to assess the degree of suitability of urban roads to bicycles as a means of transport. Finally, Rivaben *et al*. discuss agroecological paths for livestock in northern Uruguay, Muñoz-Ávila and Guerrero discuss the main synergies between the Escazú Agreement and the 2030 Agenda for sustainable development, while Streit *et al*. propose a framework to analyse cases of implementation of the circular economy from the perspective of Institutional Theory.

We wish you all a good read!

REFERENCES

COUTINHO, M. V. *et al*. The Nexus+ Approach applied to studies of impacts, vulnerability and adaptation to climate change in Brazil. **Sustainability in Debate**, v. 11, n. 3, p. 40-56, dec/2020. DOI 10.18472/SustDeb.v11n3.2020.33514

SACHS, I. **La troisième rive**: à la recherche de l'écodéveloppement. Bourin Éditeur, Paris, 2007.

SACHS, I. **Estratégias de Transição para o Século XXI**. Ed. Fundap. São Paulo, 1993.

Editorial

Ignacy Sachs (1927-2023) – pioneiro da sustentabilidade

Marcel Bursztyn, Carlos Hiroo Saito e Patrícia Mesquita

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A ideia de desenvolvimento sustentável deve muito ao professor Ignacy Sachs, que morreu no início de agosto de 2023. Pioneiro do pensamento sobre a consideração da variável ambiental como atributo indissociável da busca do desenvolvimento, Sachs se destacou como um dos conselheiros de Maurice Strong, que foi o secretário-geral da Conferência das Nações Unidas para o Meio Ambiente Humano, realizada em 1972, em Estocolmo (Suécia). Ali foi lançado o conceito de ecodesenvolvimento, que serviria de inspiração para o Relatório Nosso Futuro Comum, de 1987, em que o termo desenvolvimento sustentável foi proposto. Coordenado pela ex-primeira-ministra da Noruega, Gro Harlem Brundtland, o documento serviu de espinha dorsal para a Conferência das Nações Unidas sobre Desenvolvimento e Meio Ambiente, realizada em 1992, no Rio de Janeiro. A partir dali o debate sobre o desenvolvimento passaria a ter de considerar a questão ambiental.

Ignacy Sachs foi um economista polonês, que fugiu do Holocausto com a família quando tinha 12 anos. Em sua autobiografia (SACHS, 2007) ele narra a sua saga, até chegar em solo brasileiro, passando por vários países europeus. No Brasil, estudou economia e, ao final dos anos 1950, voltou a Varsóvia, onde trabalhou na Escola de Planejamento e Estatística, um dos berços da teoria do planejamento, sob a coordenação de Michal Kalecki. Seu doutorado teve como tema o desenvolvimento, a partir da experiência que teve durante seus estudos em Nova Delhi, na Índia. Ao longo de toda a sua vida acadêmica, Sachs sempre evocava a relevância de estudos comparativos entre Brasil e Índia, dois países que, a seu ver, deveriam servir de base e fundamento para o pensamento sobre estratégias de desenvolvimento dos países do Terceiro Mundo.

Já nos anos 1970, fundou, em Paris, o Centro de Estudos sobre o Brasil Contemporâneo – CRBC, na Escola de Altos Estudos em Ciências Sociais. Em torno dos debates semanais que organizou, passaram importantes expoentes acadêmicos e da política brasileira, naqueles tempos de ditadura militar, quando muitos viviam no exílio. Leonel Brizola, Miguel Arraes, Celso Furtado e Fernando Henrique Cardoso são alguns dos nomes de participantes dos debates.

Muitos brasileiros tiveram o privilégio de ser acolhidos como pesquisadores no CRBC, como estudantes ou pesquisadores. O primeiro a concluir doutoramento sob a sua orientação foi o professor Cristovam Buarque, decorrendo disso a inspiração para a criação do Centro de Desenvolvimento Sustentável – CDS na Universidade de Brasília, onde ele foi reitor.

Sachs teve uma presença marcante no panorama intelectual e político do Brasil pós-ditadura. Serviu de conselheiro político, consultor e principalmente referência acadêmica. Suas ideias serviram de inspiração para o surgimento dos primeiros programas de mestrado e doutorado sobre meio ambiente e sustentabilidade. O Programa de Pós-Graduação em Desenvolvimento Sustentável (mestrado e doutorado) da Universidade de Brasília e a própria revista Sustainability in Debate podem ter suas origens vinculadas a essa trajetória de ações de Sachs com influência no Brasil.

Suas obras são pilares de novos estudos e de políticas. Quando falamos sobre a bioeconomia como estratégia para um desenvolvimento sustentável na Amazônia, não podemos esquecer que Sachs teve papel pioneiro e inspirador nessa ideia, ao propor a noção de civilização da biomassa (SACHS, 1993).

Sachs foi também pioneiro no debate sobre a importância de se pensar políticas públicas de forma integrada (policy integration), evitando-se os riscos e as mazelas dos conflitos entre políticas setoriais. Já no início dos anos 1980, coordenou estudo para a Universidade das Nações Unidas, no qual lançou o conceito de Nexus, ao tratar das interfaces das políticas de biocombustíveis e de produção de alimentos. Atualmente, a abordagem Nexus é empregada em várias análises, notadamente considerando as seguranças hídrica, energética e alimentar, e mais recentemente a segurança socioambiental (COUTINHO *et al*., 2020).

Ignacy Sachs continua a nos inspirar e nos ajudar a ver a luz no fim do túnel. Com isso em mente, temos o prazer de anunciar que nosso periódico foi listado como Quartil 3 em 2023 pelo Scimago Journal and Country Rankings (https://www.scimagojr.com/journalsearch.php?q=21100824458&tip=sid&clean=0). Assim, nada mais natural do que homenagear e dedicar esta edição à memória de Ignacy Sachs.

Sigamos juntos transformando seu sonho em realidade.

Em seu segundo número de 2023, SiD publica dez artigos na seção *Varia*. Primeiramente, Cerezini e Hanai debatem sobre os desafios e diretrizes para a gestão integrada da água em bacias hidrográficas. Na sequência, Gonçalves *et al*. discutem a relação entre a dependência das indústrias por combustíveis fósseis, os desastres com petróleo e a caracterização do processo da determinação social da saúde nos territórios vulnerabilizados. Canova *et al*. investigam como as mudanças climáticas têm ameaçado a subsistência e as dimensões culturais das comunidades periurbanas na Amazônia Central, enquanto Fardin *et al*. discorrem sobre a identificação de eventos extremos de precipitação e desastres deflagrados por chuvas no município de Petrópolis-RJ.

Ribeiro destaca as possibilidades para a geração de energia a partir de biomassa no estado de Minas Gerais, enquanto Silva *et al*., por meio de um enfoque territorial, propõem uma abordagem para identificar os fatores determinantes para a inserção de mini e microssistemas de geração distribuída no setor agrícola. Já Lobo e Pinto avaliam o nível de ciclabilidade viária do município de Belo Horizonte-MG, tendo como base a proposição e análise de indicadores para avaliar o grau de adequação das vias urbanas ao uso da bicicleta como modo de transporte. E, por fim, Rivaben *et al*. debatem sobre os caminhos agroecológicos para a pecuária no norte do Uruguai, Muñoz-Ávila e Guerrero debatem as principais sinergias entre o Acordo de Escazú e a Agenda 2030 de desenvolvimento sustentável, ao passo que Streit *et al*. propõem um framework para analisar casos de implantação da economia circular sob a perspectiva da Teoria Institucional.

Desejamos uma ótima leitura a todos(as)!

REFERÊNCIAS

COUTINHO, M. V. *et al*. The Nexus+ Approach applied to studies of impacts, vulnerability and adaptation to climate change in Brazil. **Sustainability in Debate**, v. 11, n. 3, p. 40-56, dec/2020. DOI 10.18472/SustDeb.v11n3.2020.33514

SACHS, I. **La troisième rive**: à la recherche de l'écodéveloppement. Bourin Éditeur, Paris, 2007.

SACHS, I. **Estratégias de Transição para o Século XXI**. Ed. Fundap. São Paulo, 1993.

Challenges and guidelines for integrated water management in river basins: an expert view

Desafios e diretrizes para a gestão integrada da água em bacias hidrográficas: visão dos especialistas

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ABSTRACT

Integrated Water Resources Management (IWRM) is a widely accepted approach that requires technical, political, and institutional structuring for its effective implementation. An Expert Panel was created to identify Brazil's primary challenges and guidelines for water management. The participants' opinions indicated that most of the issues identified reached an agreement of 70% or higher. Among these challenges, education and participation were frequently cited by experts as central concerns. These themes were also recognised as crucial factors in addressing the challenges related to water resource management and ensuring the successful execution of the National Water Resources Policy.

Keywords: Integrated water resources management. Delphi. River basin. Water Governance.

RESUMO

A Gestão Integrada de Recursos Hídricos (Girh) é uma abordagem amplamente aceita que requer estruturação técnica, política e institucional para sua implementação efetiva. Com o objetivo de identificar os principais desafios e as diretrizes para a gestão das águas no Brasil, foi conduzido um Painel de Especialistas. A opinião dos participantes revelou que a maioria dos problemas identificados obteve uma concordância igual ou superior a 70%. Entre esses desafios, a educação e a participação foram amplamente citadas pelos especialistas como questões centrais. Esses temas também foram apontados como fundamentais nas ações e diretrizes para superar os desafios na gestão dos recursos hídricos e para a efetiva implementação da Política Nacional de Recursos Hídricos.

Palavras-chave: Gestão Integrada de Recursos Hídricos. Delphi. Bacia hidrográfica. Governança da Água.

1 INTRODUCTION

Water management from an integrated perspective has become a complex challenge due to various issues related to the use of this crucial and strategic natural resource. According to the Global Water Partnership (GWP), Integrated Water Resources Management (IWRM) is a process that aims to coordinate the development and management of water, soil, and related resources, seeking to maximise economic and social well-being fairly without compromising the sustainability of ecosystems (GWP, 2000). This definition emphasises the importance of planning and managing water with other environmental resources, ensuring its equitable and sustainable use.

The National Water Resources Policy (PNRH), Law No. 9.433/1997, introduced integrated water management in Brazil. This model represents a systemic approach to participatory integration guided by watershed-level planning, decision-making through plural and decentralised deliberations, and the establishment of legal and economic instruments that guide the rational use of water (SILVA, 2013).

In this context, Porto and Porto (2008) have suggested that, for this so-called integrated management to become feasible and achievable, a new stance is required to construct a management approach incorporating sustainable development's foundations. Thus, IWRM must consider the main principles of sustainable resource use in a multi-sectoral approach and the adoption of non-structural measures, with an emphasis on demand management (SILVA; PORTO, 2003).

Thus, water management should be based on a systemic, sustainable, and integrated approach considering the watershed as a territorial management unit involving surface and groundwater. Although the water resource legislation addresses the systemic aspect through the principle of integration, it still lacks a perspective that would integrate economic and social processes, making planning difficult and interfering with the proposition of efficient public policies (TUNDISI, 2008). To address these challenges, Tundisi and Tundisi (2016) emphasise the need for a new water governance approach that would integrate eco-hydrological processes and ecosystem services, involving the decentralisation of water management at the watershed level.

However, despite being widely accepted and disseminated, this concept demands significant technical, political, and institutional coordination and structuring for its practical implementation. To identify the main challenges and guidelines for the integrated management of water resources, the present study relied on the results of an Expert Panel, which would provide guidelines for developing and implementing actions, programs, and projects to address and overcome challenges, promoting IWRM.

2 MATERIALS AND METHODS

2.1 DATA COLLECTION

In this study, the Delphi technique was employed to identify the main challenges and necessary guidelines for integrated water management through consultations with an Expert Panel of various experts in the field.

The Policy Delphi approach (TURROF; LINSTONE, 2002) was adopted, whose objective is generating and exploring alternatives rather than attaining consensus. This method serves as an appropriate and coherent data collection tool in line with the research design and should be chosen according to the characteristics of a study, such as the need for an interdisciplinary approach and the prospects for structural changes in the sector, as is the case for IWRM (PAHL-WOSTL, 2007).

The Policy Delphi technique gathers opinions on a specific issue, facilitating policy formulation and decision-making processes (TUROFF; LINSTONE, 2002). The technique seeks to expose different stances and arguments through consultations with a group of experts, ensuring respondent anonymity, statistical representation of the results, and feedback on the responses (WRIGHT; GIOVINAZZO, 2000).

The application of the Policy Delphi method to the present study involved creating questionnaires with open and closed questions regarding water resource management, which were sent to experts in the field. Participants were selected considering stakeholders who directly or indirectly operate within the National Water Resources Management System (Singreh), covering all 27 federal units. The participants included state water resource management agency staff, members of the National Water Resources Council (CNRH) and State Water Resources Councils (Cerh), members of Basin Committees (CBH) and Water Agencies, experts from the National Water and Basic Sanitation Agency (ANA), as well as researchers and professors from universities, institutions, and research programs focused on the topic.

The estimate was to distribute questionnaires to approximately 500 individuals. Given that expert selection is a crucial step in implementing this technique, careful work was conducted to achieve balance in terms of participant representation, aiming to avoid biased results (WRIGHT; GIOVINAZZO, 2000). The research invitation letter, containing explanations about the Delphi technique, the study's objective, and the importance of participation, was sent to participants via e-mail. The study received ethics committee approval, and the contacted subjects gave written informed consent to participate in the study when completing the questionnaire.

2.2 DATA ANALYSIS

To validate the experts' responses in light of the group's opinion, the data obtained in the first-stage questionnaire were systematised and sent back to the research participants when responding to the second-round questionnaire. In this second phase, the participants were asked to indicate a level of agreement concerning the problems identified in the first stage using a Likert scale (levels: strongly agree; partially agree; strongly disagree; partially disagree; no opinion formed) and to suggest possible actions and guidelines to overcome and address the problems and obstacles presented.

At the end of the two rounds of information collection, the collected dataset was systematised and analysed. The quantitative questionnaire responses underwent simple descriptive statistical treatment to facilitate result evaluation. The Content Analysis methodology proposed by Bardin (1977) was employed to analyse open-ended responses, involving systematic steps of organisation, description, and analysis of message content. The content analysis comprised three stages: Pre-analysis, Material Exploration (coding), and Results Treatment and Interpretation.

In the Pre-analysis phase, a "floating" reading was conducted, which constitutes an initial engagement with the documents to be analysed to obtain a preliminary understanding of the material (BARDIN, 1977). In the case of the present research, the analysed material, or "corpus of analysis," consisted of the information obtained through the participants' responses. In the Material Exploration stage, the responses were coded into thematic categories, or codes, defined as sets of similar data that condense an idea. In the Results Treatment and Interpretation stage, the data were organised to propose inferences and interpretations of the results.

The Atlas.ti software, version 8.0, was used for data organisation, response coding, creation of research notes, and grouping and management of created elements. This software serves as a qualitative data analysis tool and facilitates data management and interpretation.

3 RESULTS AND DISCUSSION

The first stage of the research included 133 respondents. After compiling and analysing the obtained responses, a new questionnaire was created and sent to the same group of experts for the second and final time. The second stage of the research involved the participation of 98 experts, representing 74% of the total respondents from the previous stage. In the literature, an abstention rate of 20 to 30% in the second round is considered acceptable (WRIGHT; GIOVINAZZO, 2000).

In the first research stage questionnaire, participants were asked about the main challenges faced in water resource management within the watershed context. From the analysis of the responses to this question, it was possible to systematise codes representing categories of analysis associated with the participants' answers (Table 1). In the second research stage questionnaire, the participants were asked about the main action guidelines needed to overcome the challenges faced in integrated water resource management, as systematised in the first stage. Analysing the responses to this question made it possible to systematise the suggested action guidelines.

Table 1 | Codes and Number of occurrences in the participants' responses

Nº	*CODES*	*NUMBER OF OCCURRENCES*
1	Knowledge and Education	40
2	Participation	34
3	Managing Authority	32
4	Qualitative-Quantitative Balance	23
5	Management Instruments	21
6	Financial resources	18
7	Operational and Legal Coordination	15
8	Conflicts of Interest	14
9	Data and Information	12
10	Human Resources	11

Source: Prepared by the authors.

Regarding the Knowledge and Education code, 40 citations or excerpts were associated from the participants' responses to the question about the main challenges faced in water resource management in watersheds. From the citations associated with the Knowledge and Education code, the following issues were systematised (Table 2):

Table 2 | Codes and Number of occurrences in the participants' responses

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Lack of awareness and engagement of society regarding water issues	57%	31%	2%	8%	-
Lack of culture and education leading to community and user negligence	51%	33%	4%	10%	-
Lack of understanding and ignorance of legislation and management instruments	51%	36%	2%	9%	-
Lack of technical training for managers, basin committee members, and society	48%	37%	2%	10%	1%
Discrepancy between scientific knowledge and practical reality in water management	46%	37%	3%	12%	-

Question	Strongly Agree	Partially Agree	Strongly Disagree	Partially Disagre	No Opinion
Unfamiliarity with watershed issues and potential solutions	44%	35%	2%	17%	-

Source: Prepared by the authors.

Such issues were presented in the second stage of the research to the group of experts, who had the opportunity to indicate whether they agreed or disagreed with the challenges posed by the group. For the issues identified, there were more responses (above 80%) with options such as Strongly Agree or Partially Agree, with the most chosen response option for all questions being Strongly Agree. These results indicate that the experts agree with the issues raised within the theme, which significantly and directly impact water resource management.

The experts suggested the following guidelines to overcome the challenges identified for the Education and Knowledge theme:

- Implementing environmental education at all levels of formal and non-formal education continuously and in an integrated manner.
- Developing engaging educational materials about water resources.
- Incorporate education as an instrument of water resource policies.
- Creating formative processes directed towards managing authorities, committees, and stakeholders involved in the National Water Resources Management System (SINGREH).
- Establishing partnerships with universities, educational institutions, and research entities to promote educational activities and capacity-building.

Regarding the Participation code, 34 citations or excerpts from the participants' responses to the question about the main challenges faced in water resource management in watersheds were associated. The main related issues were then systematised based on the responses associated with the Participation code (Table 3).

Table 3 | Degree of agreement regarding issues associated with the Participation theme

Question	Strongly Agree	Partially Agree	Strongly Disagree	Partially Disagre	No Opinion
Lack of understanding and awareness about the importance of participatory management	58%	34%	1%	5%	-
Responsible entities still struggle with the participatory management model	46%	38%	4%	10%	-
Plurality of participation from various social segments is not encouraged	34%	39%	11%	14%	-
Unbalanced representation in committees and councils	32%	37%	10%	18%	1%
Limited involvement and participation of the government, users, and civil society in decision-making processes	31%	46%	5%	16%	-
Lack of legitimacy and alignment of representative participants with their group	29%	44%	8%	16%	1%

Source: Prepared by the authors.

For all the issues raised within this theme, there were a greater number of responses with options such as Strongly Agree or Partially Agree, ranging from 70% to 85%, indicating that the participants agreed with the identified issues. The data demonstrate that the participants concur with the issues raised within the Participation theme. Problems related to the lack of understanding about the importance of participatory management and the unpreparedness of responsible entities to handle this model were among those of most concern for the experts. This indicates that the participatory management model is still poorly understood by users, the population, and even the entities within the system, along with other pertinent aspects such as imbalance, lack of representation legitimacy, and limited involvement of stakeholders in decision-making processes.

Experts recommended the following guidelines to overcome challenges related to the Participation theme:

- Implementing communication, awareness, and social mobilisation programs to encourage participation.
- Providing training on participatory management and raising awareness about the importance of participation and the role of Committees.
- Establishing mechanisms to incentivise and provide financial support for the involvement of relevant stakeholders.
- Expanding the participation of underrepresented groups in decision-making processes, seeking balanced representation in Committees and Councils.
- Monitoring the effectiveness of stakeholder participation in Committees.

Regarding the Managing Authority code, 32 citations from the participants' responses to the question about the main challenges faced in water resource management in watersheds were associated. The following issues were systematised from the citations associated with the Managing Authority code (Table 4).

Table 4 | Degree of agreement regarding issues associated with the Managing Authority theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Institutional structures lacking stability, weakened and vulnerable to changes in government	63%	31%	2%	2%	-
Organisational arrangement with weak articulation and institutional integration	49%	42%	1%	5%	1%
Fragile implementation status of executive secretariats (basin agencies)	48%	29%	2%	11%	8%
Managing authorities highly influenced by political factors	43%	38%	1%	16%	
Lack of structure and managerial capacity in regional managing authorities	43%	45%	1%	8%	1%
Limited decision-making power and support for basin committee deliberations	41%	37%	5%	12%	3%

Source: Prepared by the authors.

For all the issues indicated, the options Strongly Agree or Partially Agree together accounted for more than 78% of the participants' choices. This demonstrates that the participants, on the whole, agreed with the challenges related to the Managing Authority theme and felt that the problems most concerning to experts are related to the lack of stability and institutional structure articulation and the

inefficient managerial capacity of the entities in the management system. These issues are affected by changes in government, low implementation of executive agencies, weak support for basin committee decisions, and political influences.

- To overcome the challenges identified for the Managing Authority theme, experts suggested the following guidelines:
- Enhancing the autonomy of Committees, strengthening and ensuring their decision-making power and support for decisions.
- Improving coordination among the institutions involved in water management.
- Developing support and strengthening programs for the National Water Resources Management System (Singreh).
- Reorganising managing authorities with a minimum national directive.
- Supporting the creation and strengthening of Water Agencies to alleviate the responsibilities of managing authorities.

Regarding the Qualitative-Quantitative Balance code, 23 citations or excerpts from the participants' responses to the question about the main challenges faced in water resource management in watersheds were associated. The following issues were systematised from the citations associated with the Qualitative-Quantitative Balance code (Table 5).

Table 5 | Degree of agreement regarding issues associated with the Qualitative-Quantitative Balance theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Irregular discharge of effluents in urban areas and pesticides in rural areas	78%	18%	-	2%	-
Irregular urban infrastructure compromising water quality	73%	21%	-	3%	1%
Inefficient management of basic sanitation by municipalities	73%	22%	1%	1%	1%
Challenges related to scarcity of supply and demand management	57%	37%	-	3%	1%
Traditional focus of water resource management based on flow and quality	55%	24%	4%	8%	7%
Conflicts regarding multiple water uses, priority utilisation, and equitable distribution	53%	39%	1%	5%	-

Source: Prepared by the authors.

For all the issues highlighted, the option most frequently chosen was Strongly Agree, representing more than 50% of the responses. These data demonstrate that the participants agree about the problems outlined in the Qualitative-Quantitative Balance theme. This theme received the highest levels of agreement in the responses compared to the other themes analysed by the participants, with most experts indicating their agreement with the presented issues. Among the challenges of greatest concern to experts, particularly important were the impact of urban infrastructure, irregular discharge of effluents and pesticides on water quality, and the inefficient management of basic sanitation in municipalities.

To address the challenges identified for the Qualitative-Quantitative Balance theme, experts pointed out the following guidelines:

- Implementing the National Basic Sanitation Policy in municipalities.
- Enhancing the National Hydrometeorological Network (RHN).
- Increasing the oversight of granted flow rates and urban effluents.
- Balancing the demand and supply of water in watersheds.
- Developing indicators for assessing water quality and quantity.

Twenty-one citations or excerpts from the participants' responses to the question about the main challenges faced in water resource management in watersheds were associated with the Management Instruments code, with the following issues being systematised (Table 6).

Table 6 | Degree of agreement regarding issues associated with the Management Instruments theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Disregard of Water Resources Plans by other governmental policies	71%	21%	1%	4%	1%
Lack of land use and occupation management tools for water conservation	58%	26%	5%	9%	-
Absence, outdatedness, and non-implementation of Basin Plans in committees	50%	38%	2%	6%	2%
Non-implementation of water resource policy management instruments	48%	36%	1%	13%	-
Challenges in approving and applying Water Usage Charges	40%	37%	6%	7%	8%
Formalisation of water resource usage permits with responsible authorities	30%	44%	9%	10%	5%

Source: Prepared by the authors.

Taken together, the response options Strongly Agree and Partially Agree accounted for more than 74% of the responses to all problems presented. This outcome demonstrates that, in general, the participants agreed about the problems raised within this theme, with the lack of implementation of water resource management instruments and the absence, outdatedness, and lack of coordination of basin plans with other sectoral policies being among the challenges of greatest concern to experts, notably regarding the sector's agenda.

Experts have formulated the following guidelines as a means to overcome the challenges identified in the Management Instruments theme:

- Implementing Water Resources Plans, using them as a guide for the application of other instruments and involving the society in their development.
- Expediting the permit processes and intensifying their oversight.
- Introducing water usage charges and efficiently allocating the resulting resources.
- Expanding studies and implementing water body classification.

- Implementing consolidated and accessible information systems for all stakeholders.

Eighteen citations or excerpts from the participants' responses to the question about the main challenges faced in water resource management were associated with the Financial Resources code, with the Financial Resources code, with the following issues being systematised (Table 7).

Table 7 | Degree of agreement regarding issues associated with the Financial Resources theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Scarcity of financial resources for management and planning actions in watersheds	50%	30%	4%	11%	3%
Financial precariousness of the System	47%	27%	6%	10%	8%
Inefficient oversight of the application of financial resources in the System	45%	28%	6%	9%	10%
Inability to seek new funding sources for Basin Plan actions	38%	32%	4%	13%	11%
Lack of investments in monitoring and research in water resource management	31%	56%	1%	9%	1%
Lack of financial support for the maintenance of watershed committees	30%	46%	11%	5%	6%

Source: Prepared by the authors.

Regarding the problems raised, there were more responses with the options Strongly Agree or Partially Agree, which together accounted for over 70% of the responses for each problem. This result demonstrates that the participants generally agreed with the problems raised within the Financial Resources theme, but this was one of the themes that showed the highest divergence in terms of agreement with the problems presented. For most of the aspects presented as challenges in this theme, less than half of the experts fully agreed that oversight of financial resource application is inefficient, that there is a lack of investment in monitoring and research in the field, and that there is a lack of financial support for the maintenance of Committees and Basin Plan actions.

To overcome the challenges identified in the Financial Resources theme, experts suggested the following guidelines:

- Strengthening programs and actions for financial support in water management.
- Increasing financial investment in hiring and professional qualification.
- Structuring and regulating the Water Resources Fund to enhance resource allocation in the system.
- Establishing partnerships with the third sector and private sector to expand the budget.
- Expanding monitoring and oversight of resources applied to water management.

Fifteen citations or excerpts from the participants' responses to the question about the main challenges faced in water resource management were associated with the Operational and Legal Articulation code, with the following problems being systematised (Table 8).

Table 8 | Degree of agreement regarding issues associated with the Operational and Legal Articulation theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Disconnection between land use and water management	80%	14%	1%	2%	1%
Lack of coordination between the Water Resources Policy and other sectoral policies	79%	18%	-	1%	-
Fragmented actions and efforts in water resource management	66%	27%	1%	4%	-
Operational and legal disarticulation at the municipal, state, and federal levels	64%	29%	2%	3%	-
Lack of integration between surface water and groundwater management	61%	28%	7%	1%	1%
Lack of alignment between basin priorities and watershed committee actions	35%	40%	5%	8%	10%

Source: Prepared by the authors.

The option "Agree Completely" was the response most frequently chosen regarding the top five problems identified. Overall, the participants agreed with the issues raised within the theme of Operational and Legal Coordination, and the challenges that most align with the experts' opinions are related to the lack of integration between the management of surface water, groundwater, and land use. This is one of the themes that showed the highest agreement in the participants' responses. The lack of coordination between water policy and other sectoral policies and fragmented actions in water resource management are notable obstacles to overcome.

To address the challenges identified within the theme of Operational and Legal Coordination, the experts suggested adopting the following guidelines:

- Developing a holistic vision of water management for all stakeholders involved;
- Shifting the culture from water abundance to recognising water as a finite resource;
- Promoting a dialogue between Water Resources Plans and Municipal Plans;
- Enhancing integration of water resources policy with other sectoral policies, especially land use policy;
- Strengthening integration and coordination among different institutions and levels of water resource management.

For the code "Conflicts of Interest," 14 citations or excerpts from the participants' responses were associated with the question about the main challenges faced in water resource management in watersheds. From the citations associated with the "Conflicts of Interest" code, the following problems were systematised (Table 9).

Table 9 | Degree of agreement regarding issues associated with the Conflicts of Interest theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Overlap of economic, political, and individual interests over collective interests	73%	20%	2%	3%	-
Predominance of corporate and sectoral issues in water resources management	56%	28%	1%	10%	3%

Question	Strongly Agree	Partially Agree	Strongly Disagree	Partially Disagre	No Opinion
Centralisation and political intervention by public authorities	52%	35%	3%	7%	1%
Conflicting relationships between managing entities within the political sphere	50%	33%	5%	6%	4%
Strong polarisation of decisions within government bodies	50%	35%	3%	8%	2%
Excessive vanity among stakeholders participating in committees	34%	33%	11%	15%	5%

Source: Prepared by the authors.

The "Completely Agree" option was the most frequently chosen response to all the problems presented. In general, this result shows that the participants agreed with the issues raised within the theme of Conflicts of Interest, and among the challenges indicated by the experts are the lack of prioritisation of collective interests, the predominance of sectoral issues, and political interference in water resource management.

To address the challenges identified regarding the Conflicts of Interest theme, the experts indicated the following guidelines:

- Developing political and technical instruments for conflict management.
- Implementing monitoring systems to address vulnerabilities.
- Establishing standards to reduce political and economic influence in deliberations.
- Minimising public authority interference in the management of Basin Committees for Water Resources (CBHs).
- Prioritising appointments based on technical rather than political criteria.

Regarding the Data and Information code, 12 citations or excerpts from the participants' responses were associated with the question about the main problems faced in water resource management in hydrographic basins. Based on this association, the following problems were systematised (Table 10).

Table 10 | Degree of agreement regarding problems associated with the Data and Information theme

Question	Strongly Agree	Partially Agree	Strongly Disagree	Partially Disagre	No Opinion
Disjointed databases and isolated information across various institutions and bodies	54%	37%	1%	5%	1%
Weak implementation of the National Water Resources Information System instrument	49%	39%	2%	6%	2%
Lack of transparency in sharing and dissemination of data and information	40%	34%	4%	15%	5%
Outdated and insufficient technical data for planning and management actions	39%	41%	4%	10%	4%
Excessively technical language in information presentation	28%	40%	7%	20%	3%
Manipulation of data and information	16%	30%	12%	19%	21%

Source: Prepared by the authors.

This result shows that the participants generally agreed with the issues raised within the Data and Information theme. However, it is important to note that, within this theme, the response to the problem related to data and information manipulation showed the greatest disagreement among the experts, with 46% agreeing, 31% disagreeing, and 21% having no formed opinion. This problem exhibited the lowest level of agreement among all the problems presented across all themes, which showed response agreement levels ranging from 67% to 97%.

This is an important point to analyse by indicating that experts disagree with this assertion. Other highlighted problems, according to the experts' opinion about this theme, included the insufficiency and outdated nature of technical data, the disconnection of databases, and the weak implementation of the Information System, all of which hinder planning and management actions for water resources.

The experts suggested the following guidelines in order to overcome the challenges identified for the Data and Information theme:

- Investing in research and technology to enhance data and information generation, collection, analysis, and sharing.
- Strengthening, integrating, and standardising the National Water Resources Information System (SNIRH).
- Establishing coordination among Singreh (National Water Resources Management System) entities for data and information sharing and exchange.
- Disseminating information about management instruments to the entire society.
- Improving mechanisms for the access to data by society and for information in a transparent, up-to-date, and accessible language.

Regarding the Human Resources code, 11 citations or excerpts from the participants' responses were associated with the question about the main problems faced in water resource management in hydrographic basins. Based on these associations, the following problems were systematised (Table 11).

Table 11 | Level of agreement regarding problems associated with the Human Resources theme

Question	*Strongly Agree*	*Partially Agree*	*Strongly Disagree*	*Partially Disagre*	*No Opinion*
Reduced staff size in management organizations	58%	32%	2%	4%	2%
Limited technical workforce to implement Water Resources Policy instruments	57%	34%	1%	5%	1%
Lack of qualified personnel in management and oversight agencies	47%	35%	5%	8%	3%
Lack of technical support for the maintenance of watershed committees	42%	39%	2%	10%	5%
Shortage of professionals with specific technical expertise in water resources	37%	39%	11%	9%	2%
Inexperienced team in developing projects tailored to the needs of each basin	32%	45%	6%	9%	6%

Source: Prepared by the authors.

These data show that the participants generally agreed with the problems identified for the Human Resources theme. The challenges validated by the experts are related to the limited technical workforce and the lack of qualified personnel for roles within management entities and agencies to implement water resources policy.

To overcome the challenges identified for the Human Resources theme, the experts suggested the following guidelines:

- Hiring experienced and specialised professionals with a minimum qualification requirement for roles in the field of water resources.
- Developing appreciation policies, including job descriptions and salary plans, for professionals engaged in water resources management.
- Expanding and structuring a permanent and qualified technical team to operate within management organisations.
- Appointing leadership and managerial positions based on profile and technical capability.
- Conducting public recruitment processes to fill positions in the field.

Faced with the problems and challenges identified in the research, the theme of education and capacity-building consistently emerged in all proposals and guidelines presented by the participants. Undeniably, issues related to water resources management are intrinsically linked to educational challenges. This clearly shows that educational initiatives and processes play a crucial role in pursuing IWRM, serving as a foundation for other equally essential elements in constructing this comprehensive approach.

According to the National Environmental Education Policy (Pnea), established by Law No. 9.795/99, environmental education permits the public to build values, knowledge, and skills focused on environmental conservation. Its fundamental objectives are the development of an integrated understanding of the environment, the stimulation of critical awareness of environmental and social issues, and the encouragement of participation in preserving an environmental balance as an exercise of citizenship (BRAZIL, 1999).

In this context, as highlighted by Sauvé (2005), environmental education plays a decisive role in changing community behaviour and, on a broader scale, contributes to developing more responsible societies. For Berlinck *et al*. (2003), environmental education plays a fundamental role in raising society's awareness about environmental issues in watersheds, aiding local citizenship exercise and problem-solving. By addressing conflicts related to community water use, environmental education can encourage the adoption of new behaviours and social practices, empowering individuals to be agents of change in their own reality (BERLINCK *et al*., 2003).

Approaching environmental education focusing on water resources encourages each individual to consider his responsibility for water preservation, ranging from protecting river sources to understanding that conscious use is crucial for properly managing this vital resource (D'ELIA *et al*., 2020). Thus, it is clear that the development of water resource management from an integrated perspective needs to be supported by educational and pedagogical processes for community formation and the empowerment of managers at the state and municipal levels. This should be done in an articulated and continuous manner, across all levels and modes of formal and non-formal educational processes, alongside the expansion and assurance of access to informative and educational content about water management (BERLINCK *et al*., 2003; SILVA; PORTO, 2003; TUNDISI, 2008).

The theme of participation was also extensively discussed in terms of IWRM obstacles. The participatory perspective represents one of the guiding principles of the National Water Resources Policy (PNRH), guaranteeing rights related to water use and preservation (BIANCHINI; ROCHA, 2020; BRAZIL, 1997).

For an effective participation in water management, the quality of representation of each group or segment regarding demands and responsibilities must be ensured, legitimising its interests in guaranteeing the representation of diverse needs and interests in deliberative spaces (BARBOSA *et al*.,

2016). In this sense, the participation of qualified and representative actors is essential for Committees to function as spaces for discussing interests and legitimately negotiating conflicts, ensuring the democratic and shared construction of water resource policies (JACOBI; BARBI, 2007).

Bordenave (1994) highlights that participation contributes to people's critical awareness of their reality, enabling them to assert their rights. However, it is important to understand that participation is more than just a tool for problem-solving; it is a process inherent to the social nature of human beings, an expression and assertion of oneself in relation to the others (BORDENAVE, 1994).

Effective participation occurs when local demands are heard and the needs of different groups are represented, resulting in concrete transformations. Thus, participation should be how demands, obstacles, and challenges can be overcome towards the envisioned IWRM, as only through the involvement and coordination of users, public and private entities, and civil society in decision-making processes will it be possible to ensure the legitimacy and balance of interest representation in shared and participatory water management.

The experts proposed several guidelines aiming to face the challenges identified in the pursuit of IWRM, addressing institutional strengthening, effective implementation of management instruments, financial support for the system, operational coordination, policy integration, technical team training, resolution of conflicts of interest, access to information, as well as monitoring water quality and quantity.

The literature agrees with the guidelines suggested by experts. According to Senra and Nascimento (2017), integrated management demands certain essential conditions, which include, among others, legal regulations to establish the roles and obligations of each entity involved in the process, as well as a clear delineation of management instruments and institutional functions, and active inclusion of stakeholders. Ribeiro and Hora (2019) indicate that it is essential for the entities involved to understand the new management model proposed by PNRH, as well as the instruments it encompasses.

It is imperative to reconsider the current management model and to establish more effective interactions among water resource management agencies (TRINDADE *et al*., 2022). Additionally, a reassessment of the water resource management system as a whole is needed, with a special focus on the technical capabilities of the entities comprising Singreh, aiming at a more efficient and transparent execution of their technical competencies (TRINDADE; SCHEIBE, 2019). In an articulated organisation like Singreh, such guidelines are essential to strengthen system entities and raise societal awareness about the socio-environmental issues surrounding water resource management (ANA, 2022; BRAZIL, 2022).

The National Water Resources Plan (PNRH) is the guiding document for PNRH implementation and Singreh's operation (BRAZIL, 2022). Its participatory development involved various stakeholders and society in order to obtain an inclusive approach to address challenges such as Singreh functioning, development of management instruments, management of water resource quality and quantity, technical and scientific training and development, as well as integration with other sector policies (BRAZIL, 2022). The PNRH 2022-2040 Action Plan consists of programs to respond to these challenges. Thus, its rigorous and strategic adoption emerges as an indispensable path for overcoming the obstacles highlighted by experts in this research, effectively guiding water resource management.

4 CONCLUSION

The main objective of this research was to systematically compile, based on expert opinions in the field, the key challenges and the guidelines to achieve integrated water resource management. The majority (93%) of the identified problems obtained a concordance level above 70%. The problems that achieved the highest level of agreement were: Disconnection between land use and water management; Lack of coordination between Water Resources Policy and other sector policies; and Irregular discharge

of effluents in urban areas and pesticides in rural areas, with 80%, 79%, and 78% of participants fully agreeing, respectively.

Education and participation were the themes most frequently mentioned by experts as the primary challenges faced in water resource management. These findings reveal that within the context of IWRM, education and participation emerge as crucial themes to drive progress in water management across the country, underscoring the importance of education as a foundation for promoting positive changes in other areas and topics related to water resource management.

The guidelines proposed in the present study aim to overcome key challenges and strengthen the water governance model in the country, following principles of integrated, decentralised, and participatory management. They encapsulate the fundamental aspects that must be prioritised in the water agenda according to the experts' perspective and should be valued and prioritised by governments and managers in planning and water resource management.

The interrelation of these themes is essential to effectively implement the National Water Resources Policy and achieve Integrated Water Resource Management. The strategic adoption of the National Water Resources Plan as a guiding document emerges as a fundamental approach to overcome the challenges identified by experts in this research, providing an effective guideline to enable the desired integration of water resource management in Brazil

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REFERENCES

AGÊNCIA NACIONAL DE ÁGUAS E SANEAMENTO BÁSICO. **Conjuntura dos recursos hídricos no Brasil 2021**: relatório pleno. Brasília: ANA, 2022. 132 p.

BARBOSA, F. D.; HANAI, F. Y.; SILVA, P. A. R. Participação, representação e representatividade no processo de tomada de decisão em Comitês de Bacia Hidrográfica: conceitos, reflexões e discussões. S**ustentabilidade em Debate**. Brasília, v. 7, n. 3, p. 34-46, dez/2016. Available at: https://doi.org/10.18472/SustDeb.v7n3.2016.19761

BARDIN, L. **Análise de conteúdo**. Lisboa: Editora Edições 70, 1977.

BERLINCK, C. N. *et al.* Contribuição da educação ambiental na explicitação e resolução de conflitos em torno dos recursos hídricos. **Ambiente & Educação**, v. 8, n. 1, p. 117–129, 2009.

BIANCHINI, G. C.; ROCHA, M. I. C. A participação democrática na gestão dos recursos hídricos no Brasil. R**evista de Iniciação Científica e Extensão da Faculdade de Direito de Franca**, v. 5, n. 1, 2020. Disponível em: https://doi.org/10.21207/2675-0104.2020.1132

BORDENAVE, J. E. D. **O que é participação?** 8th ed. São Paulo: Brasiliense, 1994.

BRASIL. **Lei nº 9.433, de 8 de janeiro de 1997**. Available at: http://www.planalto.gov.br/ccivil_03/LEIS/l9433.htm. Accessed on: 21 july 2023.

BRASIL. **Lei nº 9.795, de 27 de abril de 1999**. Available at: https://www.planalto.gov.br/ccivil_03/leis/l9795.htm. Accessed on: 21 july 2023.

BRASIL. **Plano Nacional de Recursos Hídricos**: Plano de Ação 2022-2040. Agência Nacional das Águas e Saneamento Básico. Brasília: ANA, 2022.

D'ELIA, R.; ARRUDA, R. O. M.; BULBOVAS, P. A Educação Ambiental e sua relevância na preservação dos recursos hídricos. **Revista Educação**, v. 15, n. 3., 2020. DOI 10.33947/1980-6469-V15N3-4416.

GLOBAL WATER PARTNERSHIP (GWP). **Integrated water resources management**. Technical Advisory Committee, Background Paper No.4. Stockholm: Global Water Partnership. 2000.

JACOBI, P. R.; BARBI, F. Democracia e participação na gestão dos recursos hídricos no Brasil. **Revista Katál**, Florianópolis, v. 10, n. 2, p. 237-244, july/dec, 2007. Available at: https://doi.org/10.1590/S1414-49802007000200012

PAHL-WOSTL, C. Transitions towards adaptive management of water facing climate and global change. **Water Resources Management**, v. 21, n. 4. 2007. Available at: https://doi.org/10.1007/s11269-006-9040-4

PORTO, M. F. A.; PORTO, R. L. L. Gestão de bacias hidrográficas. **Estudos Avançados**, v. 22, n. 63, p. 43-60. 2008.

RIBEIRO, P. E. A. M.; HORA, M. A. G. M. 20 anos da Lei n° 9.433/97: percepções dos comitês de bacia hidrográfica e dos órgãos gestores acerca da implementação da política nacional de recursos hídricos. **Rega**, v. 16, e1, 2019. Available at: https://dx.doi.org/10.21168/rega.v16e1.

SAUVÉ, L. Educação ambiental: possibilidades e limitações. **Revista Educação e Pesquisa**, São Paulo, v. 31, n. 2, p. 317-322, may/aug. 2005.

SENRA, J. B.; NASCIMENTO, N. O. Após 20 anos da lei das águas como anda a Gestão Integrada de Recursos Hídricos do Brasil, no âmbito das Políticas e Planos Nacionais setoriais. **Rega**, Porto Alegre, v. 14, n. 16, p. 1-18, 2017. DOI 10.21168/rega.v14e6

SILVA, R. T.; PORTO, M. F. A. Gestão urbana e gestão das águas: caminhos da integração. **Estudos Avançados**, v. 17, n. 47, 2003.

SILVA, T. S. A governança das águas no Brasil e os desafios para a sua democratização. **Revista UFMG**, Belo Horizonte, v. 20, n. 2, p. 236-253, july/dec. 2013.

TRINDADE, L. L. *et al*. Gestão colaborativa de bacias hidrográficas: uma visão dos comitês de bacias hidrográficas. **Rega**, v. 19, 2022. Available at: https://doi.org/10.21168/rega.v19e7

TRINDADE, L. L.; SCHEIBE, L. F. Gestão das águas: limitações e contribuições na atuação dos comitês de bacias hidrográficas brasileiros. **Ambiente & Sociedade**, v. 22, 2019. Available at: http://dx.doi.org/10.1590/1809-4422asoc20160267r2vu2019L2AO

TUNDISI, J. G.; TUNDISI, T. M. Integrating ecohydrology, water management, and watershed economy: case studies from Brazil. **Ecohydrology & Hydrobiology**, v. 16, p. 83-91, 2016. Available at: https://doi.org/10.1016/j.ecohyd.2016.03.006

TUNDISI, J. G. Recursos hídricos no futuro: problemas e soluções. **Estudos Avançados**, v. 22, n. 63, 2008. Available at: https://doi.org/10.1590/S0103-40142008000200002

TUROFF, M.; LINSTONE, H. A. **The Delphi method-techniques and applications**. 2002.

WRIGHT, J. T. C.; GIOVINAZZO, R. A. Delphi: uma ferramenta de apoio ao planejamento prospectivo. **Caderno de Pesquisas em Administração**, v. 1, n. 12, p. 54–65. 2000.

Desafios e diretrizes para a gestão integrada da água em bacias hidrográficas: visão dos especialistas

Challenges and guidelines for integrated water management in river basins: expert view

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ARTICLE – VARIA

RESUMO

A Gestão Integrada de Recursos Hídricos (Girh) é uma abordagem amplamente aceita que requer estruturação técnica, política e institucional para sua implementação efetiva. Com o objetivo de identificar os principais desafios e as diretrizes para a gestão das águas no Brasil, foi conduzido um Painel de Especialistas. A opinião dos participantes revelou que a maioria dos problemas identificados obteve uma concordância igual ou superior a 70%. Entre esses desafios, a educação e a participação foram amplamente citadas pelos especialistas como questões centrais. Esses temas também foram apontados como fundamentais nas ações e diretrizes para superar os desafios na gestão dos recursos hídricos e para a efetiva implementação da Política Nacional de Recursos Hídricos.

Palavras-chave: Gestão integrada de recursos hídricos. Delphi. Bacia hidrográfica. Governança da água.

ABSTRACT

Integrated Water Resources Management (IWRM) is a widely accepted approach that requires technical, political, and institutional structuring for its effective implementation. An Expert Panel was created in order to identify the primary challenges and guidelines for water management in Brazil. The participants' opinions indicated that most of the issues identified reached an agreement of 70% or higher. Among these challenges, education and participation were frequently cited by experts as central concerns. These themes were also recognized as crucial factors in addressing the challenges related to water resource management and ensuring the successful execution of the National Water Resources Policy.

Keywords: Integrated water resources management. Delphi. River basin. Water Governance.

1 INTRODUÇÃO

A gestão da água em uma perspectiva integrada tem se tornado um complexo desafio diante dos diversos problemas relacionados ao uso desse importante e estratégico recurso natural. De acordo com a Parceria Mundial pela Água (GWP), a Gestão Integrada de Recursos Hídricos (Girh) é um processo que visa coordenar o desenvolvimento e a gestão da água, solo e recursos relacionados, buscando maximizar o bem-estar econômico e social de maneira justa, sem comprometer a sustentabilidade dos ecossistemas (GWP, 2000). Essa definição ressalta a importância de planejar e gerenciar a água de forma integrada aos demais recursos ambientais, garantindo seu uso equitativo e sustentável.

A Política Nacional dos Recursos Hídricos (PNRH), Lei nº 9.433/1997, inaugurou a gestão integrada das águas no Brasil. Tal modelo pode ser entendido como gestão sistêmica de integração participativa, que tem como diretrizes o planejamento no nível da bacia hidrográfica, a tomada de decisão por meio de deliberações plurais e descentralizadas e o estabelecimento de instrumentos legais e econômicos que orientam o uso racional da água (SILVA, 2013).

Nesse sentido, Porto e Porto (2008) sugerem que, para viabilizar e alcançar essa gestão dita integrada, uma nova postura é exigida para a construção de uma gestão que incorpore as bases do desenvolvimento sustentável. Assim, a Girh deve considerar como principais fundamentos o uso sustentável dos recursos, a abordagem multissetorial e a adoção de medidas não estruturais, com destaque para a gestão da demanda (SILVA; PORTO, 2003).

Desse modo, a gestão da água deve considerar uma abordagem sistêmica, sustentável e integrada, considerando a bacia hidrográfica como unidade territorial de gestão e a associando à água superficial e subterrânea. Apesar de a legislação dos recursos hídricos trazer a questão sistêmica no princípio da integração, ainda é carente de uma visão que integre os processos econômicos e sociais, o que dificulta o planejamento e interfere na proposição de políticas públicas eficientes (TUNDISI, 2008). Para enfrentar esses desafios, Tundisi e Tundisi (2016) enfatizam a necessidade de uma nova governança da água, que integre processos eco-hidrológicos e serviços ecossistêmicos, implicando na descentralização da gestão da água no âmbito da bacia hidrográfica.

Assim, apesar de amplamente aceito e difundido, esse conceito exige uma grande articulação e estruturação técnica, política e institucional para que seja viabilizado nas práticas de gestão. Com o objetivo de identificar os principais desafios e as diretrizes para a gestão integrada dos recursos hídricos, esta pesquisa se baseou nos resultados de um Painel de Especialistas. Essas diretrizes servirão como orientação para a elaboração e implementação de ações, programas e projetos destinados a resolver e superar os desafios, promovendo a Girh.

2 MATERIAL E MÉTODO

2.1 COLETA DE DADOS

Neste estudo, utilizou-se a técnica Delphi com o objetivo de identificar os principais desafios e as diretrizes necessárias para uma gestão integrada da água, por meio de consultas a diversos especialistas da área, compondo um Painel de Especialistas.

Adotou-se o Delphi de Políticas (TURROF; LINSTONE, 2002), cujo objetivo é a geração e exploração de alternativas e não a obtenção de consenso, sendo um instrumento de coleta de dados adequado e coerente com o delineamento da pesquisa, visto que a escolha desse método deve se basear nas características do estudo, tais como a necessidade de abordagem interdisciplinar e as perspectivas de mudanças estruturais no setor, como é o caso da Girh (PAHL-WOSTL, 2007).

A técnica Delphi de Políticas é utilizada para obter opiniões sobre um problema específico, sendo um instrumento facilitador na elaboração de políticas públicas e no processo de tomada de decisão (LINSTONE; TUROFF, 2002). A técnica busca expor diferentes posicionamentos e argumentos, por meio de consultas a um grupo de especialistas, garantindo o anonimato dos respondentes, a representação estatística dos resultados e o feedback das respostas (WRIGHT; GIOVINAZZO, 2000).

A aplicação do método Delphi de Políticas nesta pesquisa envolveu a elaboração de questionários com perguntas abertas e fechadas sobre a gestão dos recursos hídricos, os quais foram enviados para especialistas da área. Os participantes foram selecionados considerando os atores que atuam direta ou indiretamente no Sistema Nacional de Gerenciamento de Recursos Hídricos (Singreh) de forma a contemplar as 27 unidades da Federação, entre eles: os servidores dos órgãos gestores de recursos hídricos estaduais; os membros do Conselho Nacional de Recursos Hídricos (CNRH), dos Conselhos Estaduais de Recursos Hídricos (Cerh), dos Comitês de Bacia Hidrográfica (CBH) e das Agências de Água; especialistas da Agência Nacional de Águas e Saneamento Básico (ANA); e pesquisadores e professores de universidades, instituições e programas de pesquisas voltadas ao tema.

Foi estimado o envio dos questionários para aproximadamente 500 pessoas. Considerando que a seleção dos especialistas é uma etapa importante na aplicação dessa técnica, um cuidadoso trabalho foi realizado buscando equilíbrio em relação à representatividade dos participantes, de forma a evitar resultados tendenciosos (WRIGHT; GIOVINAZZO, 2000). A carta-convite da pesquisa, contendo explicações sobre a técnica Delphi, o objetivo do estudo e a importância da participação, foi enviada aos participantes por e-mail. O estudo obteve aprovação do Comitê de Ética e os participantes concordaram com o Termo de Consentimento Livre e Esclarecido (TCLE) ao preencherem o questionário.

2.2 ANÁLISE DE DADOS

Para validar as respostas dos especialistas diante da opinião do grupo, os dados obtidos no questionário da 1ª etapa foram sistematizados e encaminhados novamente aos participantes da pesquisa no questionário da 2ª rodada. Nesse segundo momento, foi solicitado aos participantes que indicassem um nível de concordância em relação aos problemas identificados na primeira etapa, utilizando-se uma escala de Likert (níveis: concordo totalmente; concordo parcialmente; discordo totalmente; discordo parcialmente; não tenho opinião formada) e que sugerissem possíveis ações e diretrizes no sentido de superar e solucionar os problemas e obstáculos apresentados.

Ao final das duas rodadas de coleta de informações, o conjunto de dados obtido foi sistematizado e analisado. As respostas quantitativas dos questionários passaram por um tratamento estatístico descritivo simples para facilitar a avaliação dos resultados. Para a análise das respostas abertas, utilizou-se a metodologia de Análise de Conteúdo proposta por Bardin (1977), que envolve etapas sistemáticas de organização, descrição e análise do conteúdo das mensagens. A análise de conteúdo consistiu em três etapas: pré-análise; exploração do material (codificação); e tratamento dos resultados e interpretação.

Na pré-análise, realizou-se a leitura “flutuante”, que consiste em um primeiro contato com os documentos que serão submetidos à análise para obter uma compreensão inicial do material (BARDIN,1977). No caso da pesquisa aqui apresentada, o material analisado, ou “corpus de análise”, resultou das informações obtidas por meio das respostas dos participantes. Na etapa de exploração do material, as respostas foram codificadas em categorias temáticas, ou códigos, que podem ser definidos como um conjunto de dados semelhantes que condensam uma ideia. Na etapa de tratamento dos resultados e interpretação, os dados foram organizados para proposição de inferências e interpretações dos resultados.

Para a realização do processo de organização dos dados, codificação das respostas, criação de notas de pesquisa e o agrupamento e gerenciamento dos elementos criados, foi utilizado o programa Atlas.ti, versão 8.0, que consiste em um software para análise de dados qualitativos, empregado para facilitar o gerenciamento e a interpretação dos dados.

3 RESULTADOS E DISCUSSÃO

A primeira etapa da pesquisa contou com 133 respondentes. Após a compilação e análise das respostas obtidas, um novo questionário foi criado e enviado pela segunda e última vez ao mesmo grupo de especialistas. A segunda etapa da pesquisa teve a participação de 98 especialistas, representando 74% do total de respondentes da etapa anterior. Na literatura, é considerado como aceito uma abstenção de 20% a 30% na segunda rodada (WRIGHT; GIOVINAZZO, 2000).

No questionário da primeira etapa da pesquisa, foi perguntado aos participantes quais eram os principais problemas enfrentados na gestão dos recursos hídricos, no âmbito da bacia hidrográfica. A partir das análises das respostas para essa pergunta, foi possível sistematizar códigos, que representam categorias de análises, associados às respostas dos participantes (Quadro 1). No questionário da segunda etapa da pesquisa, foi perguntado aos participantes quais eram as principais diretrizes de ação para superar os problemas enfrentados na gestão integrada dos recursos hídricos, sistematizados na primeira etapa. A partir das análises das respostas para essa pergunta, foi possível sistematizar as diretrizes de ação sugeridas

Quadro 1 | Códigos e Número de ocorrências nas respostas dos participantes

Nº	*CÓDIGOS*	*NÚMERO DE OCORRÊNCIAS*
1	Conhecimento e Educação	40
2	Participação	34
3	Órgãos Gestores	32
4	Balanço Qualiquantitativo	23
5	Instrumentos de Gestão	21
6	Recursos Financeiros	18
7	Articulação Operacional e Legal	15
8	Conflitos de Interesse	14
9	Dados e Informação	12
10	Recursos Humanos	11

Fonte: Elaboração própria.

Em relação ao código “Conhecimento e Educação”, foram associadas 40 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código “Conhecimento e Educação”, foram sistematizados os seguintes problemas (Quadro 2).

Quadro 2 | Grau de concordância quanto aos problemas associados ao tema “Educação e Conhecimento”

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Falta de consciência e engajamento da sociedade em relação à questão hídrica	57%	31%	2%	8%	-
Falta de cultura e educação que culmina em descaso da comunidade e dos usuários	51%	33%	4%	10%	-

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Falta de entendimento e desconhecimento da legislação e dos instrumentos de gestão	51%	36%	2%	9%	-
Falta de capacitação técnica para gestores, membros de Comitês de Bacia e sociedade	48%	37%	2%	10%	1%
Divergência entre o conhecimento científico e a realidade prática na gestão da água	46%	37%	3%	12%	-
Desconhecimento dos problemas da bacia e das possíveis soluções	44%	35%	2%	17%	-

Fonte: Elaboração própria.

Tais problemas foram apresentados na segunda etapa da pesquisa ao grupo de especialistas, que tiveram a oportunidade de indicar se concordam ou não com os desafios expostos pelo grupo. Para os problemas indicados, houve maior número de respostas com as opções "Concordo Totalmente" ou "Parcialmente", acima de 80%, sendo que a opção de resposta mais escolhida em todas as questões foi "Concordo Totalmente". Esses resultados mostram que os especialistas concordam com os problemas levantados dentro da temática, que impactam diretamente e de forma expressiva a gestão dos recursos hídricos.

Os especialistas sugeriram as seguintes diretrizes para superação dos desafios identificados para o tema "Educação e Conhecimento":

- Implementar a educação ambiental em todos os níveis de escolaridade, formal e não formal, de forma contínua e integrada;
- Desenvolver materiais didáticos interessantes sobre os recursos hídricos;
- Incorporar a educação como um instrumento das políticas de recursos hídricos;
- Desenvolver processos formativos voltados para os órgãos gestores, colegiados e atores envolvidos no Singreh;
- Realizar parcerias com universidades e instituições de ensino e pesquisa para promoção de ações educativas e capacitação.

Em relação ao código "Participação", foram associadas 34 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das respostas associadas ao código "Participação", foram sistematizados os principais problemas relacionados (Quadro 3).

Quadro 3 | Grau de concordância quanto aos problemas associados ao tema "Participação"

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Falta de entendimento e consciência da importância da gestão participativa	58%	34%	1%	5%	-
Órgãos responsáveis ainda não sabem lidar com o modelo participativo de gestão	46%	38%	4%	10%	-
Pluralidade de participação dos diversos segmentos sociais não é estimulada	34%	39%	11%	14%	-
Representatividade nos Comitês e conselhos é desequilibrada	32%	37%	10%	18%	1%

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Pouco envolvimento e participação do poder público, dos usuários e da sociedade civil nos processos decisórios	31%	46%	5%	16%	-
Falta de legitimidade e articulação dos partícipes representantes com o seu grupo	29%	44%	8%	16%	1%

Fonte: Elaboração própria.

Para todos os problemas levantados dentro desse tema, houve maior número de respostas com as opções "Concordo Totalmente" ou "Parcialmente", entre 70% e 85%, indicando que os participantes concordaram com os problemas levantados. De forma geral, os dados demonstram que os participantes concordam com os problemas levantados dentro da temática "Participação". Os problemas relacionados à falta de entendimento da importância da gestão participativa e à falta de preparo dos órgãos responsáveis pela gestão em lidar com esse modelo estiveram entre os que mais preocupam os especialistas. Isso demonstra que o modelo de gestão participativa ainda não é compreendido pelos usuários, pela população e até mesmo pelos órgãos e entes do sistema, além de outros aspectos pertinentes ao desequilíbrio, falta de legitimidade das representações e pouco envolvimento das partes interessadas nos processos de decisão.

As seguintes diretrizes foram recomendadas pelos especialistas para superar os desafios relacionados ao tema "Participação":

- Implementar programas de comunicação, divulgação e mobilização social para incentivar a participação;
- Promover capacitação sobre gestão participativa e conscientizar sobre a importância da participação e o papel dos Comitês;
- Estabelecer mecanismos de estímulo e apoio financeiro para incentivar a participação dos atores envolvidos;
- Ampliar a participação de grupos menos representados nos processos decisórios, buscando equilíbrio da representatividade nos Comitês e Conselhos;
- Fiscalizar a efetividade da participação das partes interessadas nos Comitês.

Em relação ao código "Órgãos Gestores", foram associadas 32 citações das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Órgãos Gestores", foram sistematizados os seguintes problemas (Quadro 4).

Quadro 4 | Grau de concordância quanto aos problemas associados ao tema "Órgãos Gestores"

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Estruturas institucionais sem estabilidade, fragilizadas e vulneráveis às mudanças de governo	63%	31%	2%	2%	-
Arranjo organizacional com fraca articulação e integração institucional	49%	42%	1%	5%	1%
Frágil situação de implementação das secretarias-executivas (agências de bacias)	48%	29%	2%	11%	8%

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Órgãos gestores extremamente políticos e tendenciosos	43%	38%	1%	16%	
Falta de estrutura e capacidade gerencial dos órgãos gestores regionais	43%	45%	1%	8%	1%
Pouco poder decisório e respaldo às deliberações dos Comitês de Bacia	41%	37%	5%	12%	3%

Fonte: Elaboração própria.

Para todos os problemas indicados, as opções "Concordo Totalmente" ou "Parcialmente" somaram juntas mais de 78% da escolha dos participantes. Isso demonstra que os participantes, de maneira geral, concordam com os desafios relacionados ao tema "Órgãos Gestores" e que os problemas que mais incomodam os especialistas estão relacionados à falta de estabilidade e articulação da estrutura institucional e à ineficiente capacidade gerencial dos entes do sistema de gestão, que são prejudicados com as mudanças de governo, com a baixa implementação das agências executivas, com o fraco respaldo às deliberações dos CBHs e com as influências políticas.

Com o intuito de superar os desafios identificados em relação ao tema "Órgãos gestores", os especialistas sugeriram as seguintes diretrizes:

- Ampliar a autonomia dos Comitês, fortalecendo e assegurando seu poder decisório e respaldo às deliberações;
- Melhorar a articulação entre as instituições envolvidas na gestão da água;
- Desenvolver programas de apoio e fortalecimento do Singreh;
- Reorganizar os órgãos gestores com diretriz nacional mínima;
- Apoiar a criação e o fortalecimento das Agências de águas para aliviar as atribuições dos órgãos gestores.

Em relação ao código "Balanço Qualiquantitativo", foram associadas 23 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Balanço Qualiquantitativo", foram sistematizados os seguintes problemas (Quadro 5).

Quadro 5 | Grau de concordância quanto aos problemas associados ao tema "Órgãos Gestores"

Questão	Concordo totalmente	Concordo parcialmente	Discordo totalmente	Discordo parcialmente	Não tem opinião formada
Descargas irregulares de efluentes nos centros urbanos e agrotóxicos nas áreas rurais	78%	18%	-	2%	-
Infraestrutura urbana irregular comprometendo a qualidade da água	73%	21%	-	3%	1%
Gestão ineficiente do saneamento básico por parte dos municípios	73%	22%	1%	1%	1%
Desafios relacionados à escassez de oferta e gestão da demanda	57%	37%	-	3%	1%
Enfoque tradicional da gestão de recursos hídricos baseada na vazão e qualidade	55%	24%	4%	8%	7%
Conflitos sobre múltiplos usos da água, utilização prioritária e a distribuição equitativa	53%	39%	1%	5%	-

Fonte: Elaboração própria.

Para todos os problemas apontados, a opção mais escolhida foi "Concordo Totalmente", com mais de 50% das respostas. Os dados apresentados demonstram que os participantes concordam com os problemas apresentados para a temática do "Balanço Qualiquantitativo". Esse foi o tema que obteve os maiores níveis de concordância das respostas em relação aos demais temas analisados pelos participantes, com a maioria dos especialistas indicando que concordava com os problemas apresentados. Entre os desafios que mais preocupam os especialistas, destaca-se o impacto da infraestrutura urbana e das descargas irregulares de efluentes e agrotóxicos na qualidade das águas, assim como a gestão ineficiente do saneamento básico nos municípios.

Para enfrentar os desafios identificados em relação ao tema "Balanço Qualiquantitativo", os especialistas apontaram as seguintes diretrizes:

- Implementar a Política Nacional de Saneamento Básico nos municípios;
- Melhorar a Rede Hidrometeorológica Nacional (RHN);
- Ampliar a fiscalização das vazões outorgadas e efluentes urbanos;
- Equilibrar a demanda e a oferta de água das bacias hidrográficas;
- Desenvolver indicadores para avaliação da qualidade e quantidade das águas.

Em relação ao código "Instrumentos de Gestão", foram associadas 21 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Instrumentos de Gestão", foram sistematizados os seguintes problemas (Quadro 6).

Quadro 6 | Grau de concordância quanto aos problemas associados ao tema "Instrumentos de Gestão"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Desconsideração dos Planos de Recursos Hídricos pelas demais políticas de governo	71%	21%	1%	4%	1%
Falta de instrumentos de gestão do uso e ocupação do solo para a conservação das águas	58%	26%	5%	9%	-
Ausência, desatualização e não implementação dos Planos de Bacia nos Comitês	50%	38%	2%	6%	2%
Não implementação dos instrumentos de gestão da política de recursos hídricos	48%	36%	1%	13%	-
Dificuldades na aprovação e aplicação dos valores da Cobrança do Uso da Água	40%	37%	6%	7%	8%
Formalização da licença de uso do recurso hídrico junto aos órgãos responsáveis	30%	44%	9%	10%	5%

Fonte: Elaboração própria.

As opções de resposta "Concordo Totalmente" e "Concordo Parcialmente" somaram juntas mais de 74% das respostas em todos os problemas apresentados. Esse resultado demonstra que os participantes, de maneira geral, concordam com os problemas levantados dentro dessa temática, sendo que a falta de implementação dos instrumentos de gestão de recursos hídricos e a ausência, desatualização e desarticulação dos planos de bacia com as demais políticas setoriais estão entre os desafios que mais preocupam os especialistas, com destaque na agenda do setor.

Os especialistas elaboraram as seguintes diretrizes como forma de superação dos desafios identificados em relação ao tema "Instrumentos de Gestão":

- Implementar os Planos de Recursos Hídricos, utilizando-os como guia para a aplicação dos demais instrumentos e envolvendo a sociedade na elaboração;
- Promover a agilidade dos processos de outorga e intensificar sua fiscalização;
- Implantar a cobrança pelo uso da água e aplicar os recursos provenientes de forma eficiente;
- Ampliar os estudos e implementar o enquadramento dos corpos de água;
- Implementar sistemas de informação consolidados e acessíveis para todos os atores.

Para o código "Recursos Financeiros", foram associadas 18 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos. A partir das citações associadas ao código "Recursos Financeiros", foram sistematizados os seguintes problemas (Quadro 7).

Quadro 7 | Grau de concordância quanto aos problemas associados ao tema "Recursos Financeiros"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Recurso financeiro escasso para ações de gestão e planejamento nas bacias	50%	30%	4%	11%	3%
Precariedade financeira do Sistema	47%	27%	6%	10%	8%
Fiscalização ineficiente da aplicação dos recursos financeiros no Sistema	45%	28%	6%	9%	10%
Incapacidade de buscar novas fontes de financiamento para as ações do Plano de Bacia	38%	32%	4%	13%	11%
Falta de investimentos em monitoramento e pesquisas na área de gestão de recursos hídricos	31%	56%	1%	9%	1%
Falta de apoio financeiro para manutenção dos Comitês de Bacia Hidrográfica	30%	46%	11%	5%	6%

Fonte: Elaboração própria.

Para os problemas levantados, houve maior número de respostas com as opções "Concordo Totalmente" ou "Parcialmente", que juntas somaram mais de 70% das respostas para cada problema. Esse resultado demonstra que os participantes, de maneira geral, concordam com os problemas levantados dentro da temática "Recursos Financeiros", porém esse foi um dos temas que mais apresentaram divergências quanto à concordância com os problemas apresentados. Para a maioria dos aspectos apresentados como desafios nesse tema, menos da metade dos especialistas concordam totalmente que a fiscalização na aplicação dos recursos financeiros é ineficiente, que faltam investimentos em monitoramento e pesquisa na área e que falta apoio financeiro para a manutenção dos Comitês e ações dos Planos de Bacia.

Para superar os desafios identificados em relação ao tema "Recursos Financeiros", os especialistas sugeriram as seguintes diretrizes:

- Fortalecer os programas e ações de apoio financeiro à gestão da água;
- Ampliar o investimento financeiro para contratação e qualificação profissional;

- Estruturar, regular e descontingenciar o Fundo de Recursos Hídricos para melhorar a aplicação dos recursos no sistema;
- Estabelecer parcerias com o terceiro setor e setor privado para ampliar o orçamento;
- Ampliar o monitoramento e fiscalização dos recursos aplicados na gestão da água.

Em relação ao código "Articulação Operacional e Legal", foram associadas 15 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Articulação Operacional e Legal", foram sistematizados os seguintes problemas (Quadro 8).

Quadro 8 | Grau de concordância quanto aos problemas associados ao tema "Articulação Operacional e Legal"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Desconexão entre a gestão do uso e ocupação do solo e a gestão da água	80%	14%	1%	2%	1%
Falta de articulação entre a Política de Recursos Hídricos e as demais políticas setoriais	79%	18%	-	1%	-
Atuação e ações fragmentadas na gestão dos recursos hídricos	66%	27%	1%	4%	-
Desarticulação operacional e legal no âmbito municipal, estadual e federal	64%	29%	2%	3%	-
Falta de integração entre a gestão de águas superficiais e subterrâneas	61%	28%	7%	1%	1%
Desarticulação entre as prioridades da bacia e as ações dos Comitês de Bacia	35%	40%	5%	8%	10%

Fonte: Elaboração própria.

A opção "Concordo Totalmente" foi a resposta mais escolhida para os cinco principais problemas identificados. De modo geral, os participantes concordam com os problemas levantados dentro da temática "Articulação Operacional e Legal", e os desafios que mais convergem para a opinião dos especialistas estão relacionados à falta de integração entre a gestão das águas superficiais, águas subterrâneas e a gestão do uso e ocupação do solo. Este é um dos temas que mais apresentaram concordância nas respostas dos participantes. A falta de articulação entre a política de água e as demais políticas setoriais e a atuação fragmentada na gestão dos recursos hídricos merecem destaque quanto aos obstáculos a serem superados.

Para enfrentar os desafios identificados em relação ao tema "Articulação Operacional e Legal", os especialistas sugeriram adotar as seguintes diretrizes:

- Construir uma visão holística na gestão da água para os atores envolvidos;
- Transformar a cultura de abundância de água e reconhecê-la como um recurso finito;
- Promover o diálogo entre os Planos de Recursos Hídricos e os Planos Municipais;
- Ampliar a integração da política de recursos hídricos com as demais políticas setoriais, em especial a de uso do solo;
- Fortalecer a integração e articulação entre as diferentes instituições e esferas de gestão dos recursos hídricos.

Em relação ao código "Conflitos de Interesse", foram associadas 14 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Conflitos de Interesse", foram sistematizados os seguintes problemas (Quadro 9).

Quadro 9 | Grau de concordância quanto aos problemas associados ao tema "Conflitos de Interesse"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Sobreposição dos interesses econômicos, políticos e individuais sobre os interesses coletivos	73%	20%	2%	3%	-
Predomínio da questão corporativa e setorial na gestão dos recursos hídricos	56%	28%	1%	10%	3%
Centralização e intervenção política do poder público	52%	35%	3%	7%	1%
Relações de conflitos entre órgãos gestores na esfera política	50%	33%	5%	6%	4%
Forte polarização das decisões em órgãos do governo	50%	35%	3%	8%	2%
Vaidade excessiva dos atores que participam dos Comitês	34%	33%	11%	15%	5%

Fonte: Elaboração própria.

A opção "Concordo Totalmente" foi a mais escolhida como resposta para todos os problemas apresentados. De maneira geral, esse resultado mostra que os participantes concordam com os problemas levantados dentro da temática "Conflitos de Interesse", e entre os desafios indicados pelos especialistas estão a não priorização dos interesses coletivos, o predomínio de questões setoriais e a interferência política na gestão dos recursos hídricos.

Para lidar com os desafios identificados em relação ao tema "Conflitos de Interesse", os especialistas indicaram as seguintes diretrizes:

- Desenvolver instrumentos políticos e técnicos para a gestão de conflitos;
- Implementar sistemas de monitoramento para gerenciar as fragilidades;
- Criar normas para reduzir a influência política e econômica nas deliberações;
- Minimizar a interferência do poder público na condução dos CBHs;
- Priorizar a indicação de cargos seguindo critérios técnicos e não políticos.

Em relação ao código "Dados e Informação", foram associadas 12 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Dados e Informação", foram sistematizados os seguintes problemas (Quadro 10).

Quadro 10 | Grau de concordância quanto aos problemas associados ao tema "Dados e Informação"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Base de dados desarticulada e informações isoladas nas diversas instituições e órgãos	54%	37%	1%	5%	1%
Fraca implementação do instrumento Sistema Nacional de Informações sobre Recursos Hídricos (Snirh)	49%	39%	2%	6%	2%
Falta de transparência no compartilhamento e divulgação de dados e informações	40%	34%	4%	15%	5%
Dados técnicos desatualizados e insuficientes para as ações de planejamento e gestão	39%	41%	4%	10%	4%
Linguagem extremamente técnica na apresentação das informações	28%	40%	7%	20%	3%
Manipulação de dados e informações	16%	30%	12%	19%	21%

Fonte: Elaboração própria.

Este resultado mostra que os participantes, de maneira geral, concordam com os problemas levantados dentro da temática "Dados e Informação", porém é importante observar que dentro dessa temática o problema relacionado à manipulação de dados e informações foi o que mais obteve discordância dos especialistas, apresentando um total de 46% de concordância, 31% de discordância e 21% sem opinião formada. Esse problema apresentou o nível mais baixo de concordância entre todos os problemas apresentados de todas as temáticas, que apresentaram níveis de concordância entre 67% e 97% das respostas.

Esse é um fato importante a ser analisado e indica que os especialistas não concordam com essa afirmação. Os demais problemas que merecem destaque, de acordo com a opinião dos especialistas nesse tema, são a insuficiência e desatualização dos dados técnicos, a desarticulação das bases de dados e a fraca implementação do Sistema de Informação, que prejudicam as ações de planejamento e gestão dos recursos hídricos.

Os especialistas sugeriram as seguintes diretrizes para superação dos desafios identificados em relação ao tema "Dados e Informação":

- Investir em pesquisa e tecnologia para melhorar a geração, coleta, análise e compartilhamento de dados e informações;
- Fortalecer, integrar e padronizar o Snirh;
- Estabelecer articulação entre os órgãos do Singreh para o compartilhamento e intercâmbio de dados e informações;
- Divulgar informações sobre os instrumentos de gestão para toda a sociedade;
- Melhorar os mecanismos de acesso e divulgação dos dados e informação para a sociedade, de forma transparente, atualizada e em linguagem acessível.

Em relação ao código "Recursos Humanos", foram associadas 11 citações ou trechos das respostas dos participantes para a questão sobre os principais problemas enfrentados na gestão de recursos hídricos em bacias hidrográficas. A partir das citações associadas ao código "Recursos Humanos", foram sistematizados os seguintes problemas (Quadro 11).

Quadro 11 | Grau de concordância quanto aos problemas associados ao tema "Recursos Humanos"

Questão	*Concordo totalmente*	*Concordo parcialmente*	*Discordo totalmente*	*Discordo parcialmente*	*Não tem opinião formada*
Quadro de funcionários reduzido nos órgãos gestores	58%	32%	2%	4%	2%
Corpo técnico escasso para implementar os instrumentos da Política de Recursos Hídricos	57%	34%	1%	5%	1%
Falta de pessoal qualificado nos órgãos gestores e fiscalizadores	47%	35%	5%	8%	3%
Falta de apoio técnico para manutenção dos Comitês de Bacia Hidrográfica	42%	39%	2%	10%	5%
Falta de profissionais com capacitação técnica específica na área de recursos hídricos	37%	39%	11%	9%	2%
Equipe inexperiente na elaboração de projetos para as necessidades de cada bacia	32%	45%	6%	9%	6%

Fonte: Elaboração própria.

Esses dados mostram que os participantes, de maneira geral, concordam com os problemas indicados para o tema "Recursos Humanos". Os desafios que tiveram a validação dos especialistas estão relacionados ao escasso corpo técnico e à falta de pessoal qualificado para atuação nos entes e órgãos gestores para implementação da política de recursos hídricos.

Para superação dos desafios identificados em relação ao tema "Recursos Humanos", os especialistas sugeriram as seguintes diretrizes:

- Contratar profissionais experientes e especializados, com exigência de qualificação mínima, para atuação na área de recursos hídricos;
- Elaborar políticas de valorização, com plano de cargos e salários, dos profissionais da gestão dos recursos hídricos;
- Ampliar e estruturar quadro técnico permanente e qualificado para atuar nos órgãos gestores;
- Atribuir cargos de direção e gestão com base no perfil e capacidade técnica;
- Realizar concurso público para preenchimento de vagas na área.

Diante dos problemas e desafios identificados na pesquisa, a temática da educação e da capacitação emergiu consistentemente em todas as propostas e orientações apresentadas pelos participantes. É inegável que as questões relacionadas à gestão dos recursos hídricos estão intrinsecamente ligadas aos desafios educacionais, o que torna evidente que as iniciativas e os procedimentos educativos desempenham um papel crucial na busca pela Girh, servindo como alicerce para os outros elementos igualmente essenciais na construção dessa abordagem abrangente.

Segundo a Política Nacional de Educação Ambiental (Pnea), instituída pela Lei nº 9.795/99, educação ambiental é um processo pelo qual indivíduos e a sociedade constroem valores, conhecimentos e habilidades voltados para a conservação do meio ambiente. Seus objetivos fundamentais são o desenvolvimento de uma compreensão integrada do meio ambiente, o estímulo à consciência crítica sobre questões ambientais e sociais, e o incentivo à participação na preservação do equilíbrio ambiental como exercício de cidadania (BRASIL, 1999).

Nesse sentido, como destaca Sauvé (2005), a educação ambiental possui papel decisivo para a mudança de comportamento da comunidade e, em uma perspectiva mais ampla, ela contribui para o desenvolvimento de sociedades mais responsáveis. Para Berlinck *et al*. (2003), a educação ambiental desempenha um papel fundamental na conscientização da sociedade sobre os problemas ambientais nas bacias hidrográficas, auxiliando no exercício da cidadania local e na busca por soluções. Por meio da problematização dos conflitos relacionados ao uso da água pela comunidade, a educação ambiental pode incentivar a adoção de novos comportamentos e práticas sociais, capacitando o indivíduo a ser um agente de transformação em sua própria realidade (BERLINCK *et al*., 2003).

Abordar a educação ambiental com foco nos recursos hídricos incentiva cada indivíduo a considerar sua responsabilidade na preservação da água, abrangendo desde a proteção dos mananciais até a compreensão de que o uso consciente é crucial para a gestão adequada desse recurso vital (D'ELIA *et al*., 2020). Assim, fica claro que o desenvolvimento da gestão dos recursos hídricos em uma perspectiva integrada precisa ser apoiado por processos educacionais e pedagógicos para a formação da comunidade e capacitação dos gestores no âmbito estadual e municipal, de forma articulada e contínua, em todos os níveis e modalidades dos processos educativos formais e não formais, além da ampliação e garantia de acesso à oferta de conteúdos informativos e educativos sobre a gestão da água (BERLINCK *et al*, 2003; SILVA; PORTO, 2003; TUNDISI, 2008).

O tema da participação também foi amplamente discutido em relação aos obstáculos da Girh. A perspectiva participativa representa um dos pilares orientadores da PNRH, sendo fundamental para garantir os direitos relacionados ao uso e preservação da água (BIANCHINI; ROCHA, 2020; BRASIL, 1997).

Para que o processo da participação na gestão da água seja efetivo, é preciso assegurar a qualidade da representação das demandas e obrigações de cada grupo ou segmento, legitimando seus interesses de forma a garantir a representatividade das distintas necessidades e interesses nos espaços deliberativos (BARBOSA *et al*., 2016). Nesse sentido, a participação de atores qualificados e representativos é fundamental para que os Comitês funcionem como espaços para discussão dos interesses e negociação dos conflitos de forma legítima, garantindo a construção democrática e compartilhada da política de recursos hídricos (JACOBI; BARBI, 2007).

Conforme destaca Bordenave (1994), a participação contribui para a construção da consciência crítica dos indivíduos em relação à sua realidade, capacitando-os para reivindicar seus direitos. No entanto, é importante compreender que a participação vai além de ser apenas um instrumento para resolver problemas, sendo um processo inerente à natureza social do ser humano, de expressão e afirmação de si mesmo e com os outros (BORDENAVE, 1994).

A participação efetiva ocorre quando as demandas locais são ouvidas e as necessidades dos diferentes grupos são representadas, resultando em transformações concretas. Dessa forma, a participação deve ser o meio pelo qual as demandas, obstáculos e desafios possam ser superados em direção à idealizada Girh, pois somente com o envolvimento e articulação dos usuários, do poder público e privado e da sociedade civil nos processos decisórios serão garantidos a legitimidade e o equilíbrio da representação dos interesses na gestão compartilhada e participativa da água.

Os especialistas sugeriram diversas diretrizes para superar os desafios identificados na busca pela Girh, abordando o fortalecimento das instituições, a implementação efetiva dos instrumentos de gestão, o apoio financeiro ao sistema, a coordenação operacional, a integração das políticas, a capacitação da equipe técnica, a resolução de conflitos de interesse, a obtenção e acesso às informações, bem como o monitoramento da qualidade e quantidade da água.

A literatura corrobora as diretrizes sugeridas pelos especialistas. De acordo com Senra e Nascimento (2017), a gestão integrada exige certas condições essenciais, que incluem, entre outras, a regulamentação legal para estabelecer as atribuições e obrigações de cada ente envolvido no processo, além do claro delineamento dos instrumentos de gestão e das funções institucionais, bem como a inclusão ativa das partes interessadas. Ribeiro e Hora (2019) indicam que é essencial que os entes envolvidos entendam o novo modelo de gestão proposto pela PNRH, bem como os instrumentos que ele abrange.

É imperativo reconsiderar o modelo de gestão atual e estabelecer interações mais eficazes entre os órgãos de gestão dos recursos hídricos (TRINDADE *et al*., 2022). Além disso, é necessário reavaliar o sistema de gestão dos recursos hídricos como um todo, focando especialmente as capacidades técnicas dos órgãos que compõem o Singreh, visando uma execução mais eficaz e transparente das suas competências técnicas (TRINDADE; SCHEIBE, 2019). Em uma organização articulada, como o Singreh, tais diretrizes são fundamentais para fortalecer os entes do sistema e sensibilizar a sociedade para as questões socioambientais que envolvem a gestão dos recursos hídricos (ANA, 2022; BRASIL, 2022).

O Plano Nacional de Recursos Hídricos (PNRH) é o documento orientador da implementação da PNRH e da atuação do Singreh (BRASIL, 2022). Sua elaboração participativa envolveu diversos atores e a sociedade, buscando uma abordagem inclusiva para lidar com desafios, como o funcionamento do Singreh, o desenvolvimento dos instrumentos de gestão, a gestão da qualidade e quantidade dos recursos hídricos, a capacitação e o desenvolvimento técnico e científico, bem como a integração com outras políticas setoriais (BRASIL, 2022). O Plano de Ação do PNRH 2022-2040 é composto por programas que buscam dar resposta a esses desafios. Assim, a sua adoção rigorosa e estratégica emerge como um caminho indispensável para a superação dos obstáculos destacados pelos especialistas nesta pesquisa, guiando efetivamente a gestão dos recursos hídricos.

4 CONCLUSÕES

Esta pesquisa teve como objetivo principal sistematizar, a partir das opiniões dos especialistas da área, os principais desafios e as diretrizes para alcançar a gestão dos recursos hídricos em uma perspectiva integrada. A maioria (93%) dos problemas identificados obteve grau de concordância acima de 70%. Os problemas que obtiveram o maior nível de concordância foram: desconexão entre a gestão do uso e ocupação do solo e a gestão da água; falta de articulação entre a Política de Recursos Hídricos e as demais políticas setoriais; e descargas irregulares de efluentes nos centros urbanos e agrotóxicos nas áreas rurais, com 80%, 79% e 78%, respectivamente, dos participantes concordando totalmente.

Os temas educação e participação foram os mais mencionados pelos especialistas como os principais problemas enfrentados na gestão dos recursos hídricos. Esses resultados revelam que, no contexto da Girh, a educação e a participação emergem como temas fundamentais para impulsionar o avanço na gestão da água no país, e reforçam a importância da educação como base para fomentar mudanças positivas nas demais áreas e temáticas relacionadas à gestão dos recursos hídricos.

As diretrizes propostas neste trabalho visam superar os principais desafios e fortalecer o modelo de governança das águas no país, seguindo os princípios de gestão integrada, descentralizada e participativa. Elas sistematizam os aspectos fundamentais que devem ser priorizados na agenda hídrica, de acordo com a visão dos especialistas, e devem ser valorizadas e priorizadas pelos governos e gestores, tanto no planejamento quanto na gestão dos recursos hídricos.

A inter-relação desses temas é fundamental para implementar efetivamente a Política Nacional de Recursos Hídricos e alcançar a Gestão Integrada de Recursos Hídricos. A adoção estratégica do Plano Nacional de Recursos Hídricos como documento orientador surge como um aspecto fundamental para superar os desafios identificados pelos especialistas nesta pesquisa, proporcionando uma diretriz eficaz para viabilizar a implementação da almejada integração da gestão dos recursos hídricos do Brasil.

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REFERÊNCIAS

AGÊNCIA NACIONAL DE ÁGUAS E SANEAMENTO BÁSICO. **Conjuntura dos recursos hídricos no Brasil 2021**: relatório pleno. Brasília: ANA, 2022. 132 p.

BARBOSA, F. D.; HANAI, F. Y.; SILVA, P. A. R. Participação, representação e representatividade no processo de tomada de decisão em Comitês de Bacia Hidrográfica: conceitos, reflexões e discussões. **Sustentabilidade em Debate**. Brasília, v. 7, n. 3, p. 34-46, dez/2016. Disponível em: https://doi.org/10.18472/SustDeb.v7n3.2016.19761

BARDIN, L. **Análise de conteúdo**. Lisboa: Editora Edições 70, 1977.

BERLINCK, C. N. *et al*. Contribuição da educação ambiental na explicitação e resolução de conflitos em torno dos recursos hídricos. **Ambiente & Educação**, v. 8, n. 1, p. 117–129, 2009.

BIANCHINI, G. C.; ROCHA, M. I. C. A participação democrática na gestão dos recursos hídricos no Brasil. **Revista de Iniciação Científica e Extensão da Faculdade de Direito de Franca**, v. 5, n. 1, 2020. Disponível em: https://doi.org/10.21207/2675-0104.2020.1132

BORDENAVE, J. E. D. **O que é participação?** 8ª ed. São Paulo: Brasiliense, 1994.

BRASIL. **Lei nº 9.433, de 8 de janeiro de 1997**. Disponível em: http://www.planalto.gov.br/ccivil_03/LEIS/l9433.htm. Acesso em: 21 jul. 2023.

BRASIL. **Lei nº 9.795, de 27 de abril de 1999**. Disponível em: https://www.planalto.gov.br/ccivil_03/leis/l9795.htm. Acesso em: 21 jul. 2023.

BRASIL. **Plano Nacional de Recursos Hídricos**: Plano de Ação 2022-2040. Agência Nacional das Águas e Saneamento Básico. Brasília: ANA, 2022.

D'ELIA, R.; ARRUDA, R. O. M.; BULBOVAS, P. A Educação Ambiental e sua relevância na preservação dos recursos hídricos. **Revista Educação**, v. 15, n. 3., 2020. DOI 10.33947/1980-6469-V15N3-4416.

GLOBAL WATER PARTNERSHIP (GWP). **Integrated water resources management**. Technical Advisory Committee, Background Paper No.4. Stockholm: Global Water Partnership. 2000.

JACOBI, P. R.; BARBI, F. Democracia e participação na gestão dos recursos hídricos no Brasil. **Revista Katál**, Florianópolis, v. 10, n. 2, p. 237-244, jul/dez, 2007. Disponível em: https://doi.org/10.1590/S1414-49802007000200012

PAHL-WOSTL, C. Transitions towards adaptive management of water facing climate and global change. **Water Resources Management**, v. 21, n. 4. 2007. Disponível em: https://doi.org/10.1007/s11269-006-9040-4

PORTO, M. F. A.; PORTO, R. L. L. Gestão de bacias hidrográficas. **Estudos Avançados**, v. 22, n. 63, p. 43-60. 2008.

RIBEIRO, P. E. A. M.; HORA, M. A. G. M. 20 anos da Lei n° 9.433/97: percepções dos comitês de bacia hidrográfica e dos órgãos gestores acerca da implementação da política nacional de recursos hídricos. **Rega**, v. 16, e1, 2019. Disponível em: https://dx.doi.org/10.21168/rega.v16e1.

SAUVÉ, L. Educação ambiental: possibilidades e limitações. **Revista Educação e Pesquisa**, São Paulo, v. 31, n. 2, p. 317-322, maio/ago. 2005.

SENRA, J. B.; NASCIMENTO, N. O. Após 20 anos da lei das águas como anda a Gestão Integrada de Recursos Hídricos do Brasil, no âmbito das Políticas e Planos Nacionais setoriais. **Rega**, Porto Alegre, v. 14, n. 16, p. 1-18, 2017. DOI 10.21168/rega.v14e6

SILVA, R. T.; PORTO, M. F. A. Gestão urbana e gestão das águas: caminhos da integração. **Estudos Avançados**, v. 17, n. 47, 2003.

SILVA, T. S. A governança das águas no Brasil e os desafios para a sua democratização. **Revista UFMG**, Belo Horizonte, v. 20, n. 2, p. 236-253, jul./dez. 2013.

TRINDADE, L. L. *et al*. Gestão colaborativa de bacias hidrográficas: uma visão dos comitês de bacias hidrográficas. **Rega**, v. 19, 2022. Disponível em: https://doi.org/10.21168/rega.v19e7

TRINDADE, L. L.; SCHEIBE, L. F. Gestão das águas: limitações e contribuições na atuação dos comitês de bacias hidrográficas brasileiros. **Ambiente & Sociedade**, v. 22, 2019. Disponível em: http://dx.doi.org/10.1590/1809-4422asoc20160267r2vu2019L2AO

TUNDISI, J. G.; TUNDISI, T. M. Integrating ecohydrology, water management, and watershed economy: case studies from Brazil. **Ecohydrology & Hydrobiology**, v. 16, p. 83-91, 2016. Disponível em: https://doi.org/10.1016/j.ecohyd.2016.03.006

TUNDISI, J. G. Recursos hídricos no futuro: problemas e soluções. **Estudos Avançados**, v. 22, n. 63, 2008. Disponível em: https://doi.org/10.1590/S0103-40142008000200002

TUROFF, M.; LINSTONE, H. A. **The Delphi method-techniques and applications**. 2002.

WRIGHT, J. T. C.; GIOVINAZZO, R. A. Delphi: uma ferramenta de apoio ao planejamento prospectivo. **Caderno de Pesquisas em Administração**, v. 1, n. 12, p. 54–65. 2000.

Social determination of health of small-scale fishing workers in oil disasters

Determinação social da saúde de trabalhadores da pesca artesanal em desastres com petróleo

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ARTICLE- VARIA

ABSTRACT

This essay reflects on the oil-dependent model and its relationship with vulnerability in the health of small-scale fishing communities from the Social Determination of Health perspective. Three analysis axes were structured as follows: characterising the industry's dependence on fossil fuels and the consequences for the populations of the affected territories; the Brazilian oil disaster crime in 2019; and finally, considering Breilh's conception (2013), characterising the social determination of health in the vulnerable territories affected by these disasters. The notion of health dissociated from social, cultural, economic, spiritual, and political constructions represents an insufficient model for analysing the health-disease process, identifying a fragmented being and disregarding the overlapping of "inorganic" layers that suppresses and reorganises existence.

Keywords: Petroleum Pollution. Disaster vulnerability. Environmental health. Health-Disease Process.

RESUMO

Este ensaio apresenta reflexões sobre o modelo por petróleo dependente e sua relação com os processos de vulnerabilização na saúde das comunidades da pesca artesanal sob a perspectiva da determinação social da saúde. Estruturou-se em três eixos de análise: a caracterização do processo de dependência dos combustíveis fósseis pela indústria e as consequências para as populações dos territórios afetados; o desastre-crime do petróleo ocorrido no Brasil a partir de 2019 e, por fim, à luz da concepção de Breilh (2013), a caracterização do processo da determinação social da saúde nos territórios vulnerabilizados e afetados por esses desastres. A noção de saúde dissociada das construções sociais, culturais, econômicas, espirituais e políticas conforma um modelo insuficiente na análise do processo saúde-doença, identificando um ser fragmentado e desconsiderando a sobreposição de camadas "inorgânicas" que suprime e reorganiza a existência.

Palavras-chave: Poluição por petróleo. Vulnerabilidade a desastres. Saúde ambiental. Processo saúde-doença.

1 INTRODUCTION

Energy models dependent on non-renewable matrices, such as oil, play a primary role in the global climate crisis and determine extreme weather events. They also advance deforestation, destroy biomes, and trigger diseases and food and nutrition insecurity (EL-SAYED; KAMEL, 2020; PATZ *et al*., 2014). While the association between the consumption of fossil fuels, such as oil, and the climate crisis is known, the global installation of petrochemical complexes is recurrent. It raises different narratives for the transition to renewable energy sources, especially in developing countries (VIGLIO *et al*., 2019).

We observe different levels and types of human exposure to pollutants, especially workers in this production chain, the contamination of fauna and flora, and disasters caused by oil production activities (extraction, refining, and other operations). These events trigger socioenvironmental vulnerability, compromising material and symbolic aspects and affecting people's health, especially vulnerable populations (GURGEL, 2011; SANTOS *et al*., 2019; SOARES *et al*., 2021).

Disasters such as oil spills are a systemic problem. They can entail ecological and socioeconomic harm, with implications for ecosystems and human health around the projects or coastal areas, such as small-scale fishing communities. They are an environmental and public health emergency issue of concern (CARMO; TEIXEIRA, 2020; GURGEL, 2011; PENA *et al*., 2020; SANTOS, 2019; SILVA *et al*., 2022).

Studies from complex and systemic perspectives on the health-disease process of affected communities can provide us with alternatives to improve life in communities affected by these disasters. Theoretical-conceptual aspects of the social determination of health in Latin America are proven to be a way toward apprehending harm and diseases from a complex analysis and contributing to action plans in these contexts.

This essay aims to reflect on the oil-dependent model and its relationship with vulnerability in the health of small-scale fishing communities from the perspective of the social determination of health. This work was structured from the historical and dialectical perspective of the social determination of health proposed by epidemiologist Jaime Breilh (2013) to comprehend collective health.

Three axes of analysis were defined from the identified scientific literature: initially, we featured the industry's dependence on fossil fuels, particularly in Brazil, and the implications for the populations in the affected territories. Then, we underscored the Brazilian oil crime disaster in 2019 and its reverberations on small-scale fishing communities, considering issues related to small-scale fishing management, anthropic actions in the environment, and harm to the health of small-scale fishermen. Finally, in light of Breilh's conception (2013), we featured the social determination of health in these vulnerable territories affected by such disasters.

2 STRUCTURAL TRANSFORMATIONS: THE OIL-DEPENDENT INDUSTRY

The significant oil valorisation primarily stems from three principal milestones in the 1970s: a) the United States losing its centrality in oil production, sharing space with the Middle East; b) the oil barrel price hike in 1973, when it almost tripled in value and started to be used as a contention instrument in the Middle East, which holds most of the good quality oil reserves globally; and c) the second oil crisis in 1979, when Iran, second-largest producer at the time, cut its exports (D'ALMEIDA, 2015, 2019; GASPAR, 2015). Such facts boosted the extraction of this finite resource, entailing vulnerability in the lives of subjects and territories residing in the territories of the implemented projects. We should consider territorial vulnerability originates from historical and social relationships and processes extending beyond the biological dimension, marked by environmental and social injustice (BREILH, 2013; GURGEL, 2011, 2019; PORTO, 2014; SANTOS, 2019).

In Brazil, oil prevails among the primary sources of fossil fuels employed in the energy matrix, including natural gas and mineral coal. On the other hand, solar energy, hydraulic energy, biomass, and wind energy are renewable sources representing about 44.7% of the energy used in Brazil. We highlight the use of large hydroelectric/wind power plants and sugarcane derivatives, which can also develop risks and harm to health and the environment, although oil and its derivatives remain a structural element of the Brazilian energy matrix (EPE, 2022; SANTOS, 2019).

Several Brazilian states, especially in the Northeast region, have expanded their petrochemical complex by implementing industries and port complexes, such as the Abreu e Lima Refinery (RNEST) and Petrochemical Plant Suape in Pernambuco; the Potiguar Clara Camarão Refinery in Rio Grande do Norte; the expanded Camaçari Petrochemical Complex in Bahia; and the Premium I and Premium II Refineries, which would be installed in Maranhão and Ceará respectively, but whose works were cancelled in 2015 (GURGEL, 2011; PÉREZ, 2016; SANTOS, 2017; SILVA, 2017).

The scale-up installation of these refineries is also inversely proportional to their territory's organisational rationale, causing vulnerability, escalated conflict and environmental injustice, environmental pollution, and chemical exposure that compromise people's health and quality of life (DOMINGUES *et al*., 2014; SANTOS, 2017; SANTOS *et al*., 2022).

Oil chain-associated disasters can harm marine ecosystems and those dependent on them (PENA *et al*., 2020; SILVA *et al*., 2022). One of the most critical aspects related to the implementation of large undertakings such as these is concealing problems and changing their construction and operation entail to the territory where people live and work, such as the violation of human rights and socio-environmental injustice (CPP, 2021; SANTOS, 2011, 2017).

Respiratory, neurological, liver, kidney, endocrine, haematological, and other diseases are other effects of direct exposure to oil and its derivatives (LAFFON, 2016). There could be acute or chronic physiological effects, and there is no safe exposure threshold for specific effects, such as cancer (CROISANT; SULLIVAN, 2018; RIBEIRO, 2012).

The loss of fishing territory, environmental devastation, and the substandard conditions of small-scale fishing are examples of primary human and ecological rights violations that distinguish the reality of these Brazilian communities. The current historical moment is marked by profound ecological, economic, and social crises and requires reformulating the oil-dependent production model in light of the very limits of nature (MARTINEZ-ALIER *et al*., 2016).

In August 2019, large oil slicks were recorded on beaches in the northeastern coastal Brazilian states, also reaching the country's southeast. Eleven states, 130 municipalities, 1,009 locations, and more than 3,000 km of the Brazilian coastline were affected, resulting in the largest extensive disaster in Brazil. More than 5,300 tons of oil residues were reportedly collected from the beaches (MESQUITA; QUINAMO, 2020; REDDY, 2022; SOARES, 2022).

Small-scale fishermen were among the most affected populations. Oil directly affected their territories, affecting life in the mangroves, sea, and beaches. During the period, the media engaged in disinformation and cover-up, arbitrarily announcing the contamination of all fish and shellfish on the coast, which led to vulnerability due to the sudden decline in the sale of fish and shellfish, which in turn entailed extensive financial losses to fishermen (PENA *et al*., 2020; SANTOS *et al*., 2022).

Mental distress was also identified as a result of this experience, especially concerning lack of work and loss of income. In similar disasters, as with the explosion of the Deepwater Horizon platform in the Gulf of Mexico, the oil spill was a national fish consumption-related security issue, contributing to mental distress and work, health, and lifestyle encumbrance of these people (GOLDSTEIN *et al*., 2011; MOREIRA, 2017).

3 SMALL-SCALE FISHING COMMUNITIES AND OIL DISASTER CRIME REPERCUSSIONS

Water people's knowledge builds on the use, observation, coexistence, and dependence on the natural resources in the marine and continental environments, as recommended by the National Policy for the Comprehensive Health of Rural, Forest and Water Population to protect and qualify health care access for these populations in Brazil, "these peoples' and communities' lifestyle, production, and social reproduction are predominantly related to water environments", such as small-scale fishermen (BRASIL, 2014, art. 2°).

Artisanal fishermen are characterised by small-scale fishing activities, landed or in small boats, to capture different species of fish, shellfish, and crustaceans for sale through direct buyers, go-betweens, and at fairs and public markets (RÊGO *et al*., 2018). Fishing also takes on an affective and food consumption dimension for coastal populations.

The fishing community, other peoples, and traditional communities are part of a specific set of populations that reproduce their traditional lifestyles characterised by relative autonomy (BRANDÃO, 2010). Small-scale fishermen's lifestyle is linked to healthy and sustainable productive conditions in the sense of subsistence in the natural environment – tides, rivers, estuaries, and mangroves.

Brazil is one of the largest fish producers in Latin America, ranking 18th globally; an approximative data since Brazil has not made official fishing production data available since 2014 (FAO, 2020, p. 21). Thus, despite the cultural and productive relevance of these people, the registration of small-scale fishery workers by the Brazilian government needs to be updated. Furthermore, existing data are not adequately organised, hindering the retrieval of reliable data (MENDONÇA; MATTOS, 2021).

We highlight three issues faced by small-scale fishermen that directly impact working and living conditions: 1) small-scale fishing political management problems; 2) anthropic-derived environmental problems; 3) harm to health caused by the small-scale fishing work activity.

In the political and public management fields, the regulation of small-scale fishing activity started with the organisational training of fishermen in colonies, that is, in social organisations representing small-scale fishing activity, currently responsible for recognising individual professionalisation (OLIVEIRA; SILVA, 2012). Fishing activity governance endured more than one hundred years of instability after the natural establishment of colonies among fishermen between the Ministries of the Navy and Agriculture.

In the meantime, a significant increase was observed in the number of colonies across the national territory, which has approximately 800 units of this type, resulting from the Navy's clear intention to encourage militarisation by fostering national defence by sea and significantly boost the country's economic development, as fishermen would stand at strategic points at sea (SILVA, 2014). The modernisation of national productive practices, mainly agriculture and fishing, underlies the idea of mechanising activities for the 'nation's economic development' (CUNHA, 2012).

Modernising small-scale fishing was related to encouraging the sector's industrialisation. It was mainly supported by political actions, such as enacting the Fisheries Code in 1967, which regulates fishing activities. Brazil promoted industrial fishing based on financial incentives and exemption from some product and machinery levies while neglecting small-scale fishing. As a result, small-scale fishing could have been more characterised, making these communities' identities and social reproduction vulnerable. Some authors argue that the considerable increase in industrial fishing can deplete different fish species, mainly harming small-scale fishermen (GUIMARÃES; LEITÃO, 2020).

In the advances in the legislative field, Law Nº 10.779/2003 established in Brazil a legal regulation aimed at securing social rights for small-scale fishing, granting labour benefits such as unemployment insurance during the species' reproduction period – when fishing is not allowed to preserve the species (BRASIL, 2003). Fishing Law N° 11.959/2009 did not update social rights but legalised small-scale fishing, allowing low-interest loans to preserve this sector's operations (BRASIL, 2009). As a result, Oliveira and Silva (2012) emphasised the relevance of the, albeit late, legal regulation of small-scale fishing:

> The regulation of the activity enables the professional recognition of workers. So, the fisherman starts to benefit from all the rights arising from work activities, especially regarding social security benefits. Last, regulation is a means to assert public policies to encourage community and non-industrial activities, neglected and even suppressed by Brazilian authoritarian regimes (OLIVEIRA; SILVA, 2012, p.10).

Besides labour guarantees for regulating the fishing profession, the legal systems must also be reflected in working conditions intertwined with preserving and protecting nature. They should even formulate protocols and instruments such as contingency plans, disaster preparedness, and response plans to curb harm to affected communities or populations (FREITAS *et al*., 2018).

The lack of these legal frameworks or their operationalisation, as in the oil crime disaster in 2019, reflects the insufficient governmental actions that have severely affected the health and the environment due to oil-derived exposure and contamination (RAMALHO; SANTOS, 2021; SOARES *et al*., 2020). However, this fact should not be analysed on a stand-alone basis as it is overdetermined by historical and social processes that affect these territories.

The second group of problems – anthropic action in fishing environments – is related to the changes imposed on traditional territories caused mainly by the industrialised economic activities, the establishment of large undertakings such as hydroelectric/power/steelwork plants and urbanisation, for example, and agribusiness, neo-extractivism, disasters, or environmental crimes. They result in deterritorialised fishing communities, disrupted social reproduction of these groups, pollution in fishing environments, impracticable fishing activity, search for other productive activities, and long travel to other fishing areas (PAULA, 2018).

The frequent oil accidents are some examples of how the ideals of unbridled modernity can attach incalculable harm to traditional communities and the environment. They produce harm in the medium and long term, escalating socioeconomic, environmental, and health vulnerability, especially for communities socioeconomically dependent on tourism and small-scale fishing, and the ecosystems where they reside, such as coral reefs, estuaries, and mangroves, often establishing emotional bonds with these places. However, studies analysing these impacts from a complex viewpoint are still incipient, considering the reverberation of these disasters on this population's living and health conditions (SILVA, 2022).

The third group is related to health risks linked to fishing activity. Pena and Minayo (2014) found about thirty different types of diseases related to the work process and living conditions in fishing communities in Bahia state. Some of the exposures and problems identified are similar to those observed in small-scale fishermen in Pernambuco, such as sun exposure, systemic arterial hypertension, overweight or obesity, tobacco and alcohol abuse, repetitive strain injuries, weight overload, and respiratory problems caused by the constant use of firewood (PENA; MARTINS, 2014).

These health problems result from the long and strenuous working hours to which small-scale fishing workers are subjected (FALCÃO *et al*., 2019; PENA *et al*., 2014). Besides the illnesses already mentioned, we should stress that the oil spill engendered new illnesses in the territories from oil exposure and mental distress caused by income loss and work environment contamination (RAMALHO; SANTOS, 2021; SILVA *et al*., 2022).

Although small-scale fishing is an autonomous activity, it is a way of life and production not solely aimed at profit. However, it has a solid community base, as several stages of the production process involve and depend on different community stakeholders – those catching fish/shellfish, those processing the products, and those selling the products. Thus, the chain is fed to ensure these individuals' livelihoods (NASCIMENTO, 2022; PENA *et al*., 2013; PENA; GOMES, 2014; PENA *et al*., 2014).

The oil spill interrupted this organisation, compromising the production chain and livelihoods. The lack of actions by government institutions and media outlets sharing news without scientific basis strengthened and legitimised the constructed imaginary that all fish was unfit for consumption, reducing sales by around 80% to 100% in the months following the onset of the disaster (ARAÚJO *et al*., 2020).

4 SOCIAL DETERMINATION OF HEALTH AS AN EMANCIPATORY ANALYSIS TOOL

We identified the need to understand the oil spill impacts on the health of the affected communities from the brief discussion of the problems that permeate the lives of water people. A complex and systemic analysis is required to grasp how the environment is central to preserving their productive activities, cultural practices, way of life, and social reproduction. In this sense, the Social Determination of Health aims to integrate health into the social frameworks of life in a broad, complex, and profound sense. (BREILH, 2013; PESSOA *et al*., 2018).

> This means that the sequence of social determinations, from the most general features of society, the global socioeconomic macro-determinants, to the most particular ones, from small groups and interpersonal relationships, shape individualities, but these are active in choosing themselves, manifesting actively in their choices and actions (FLEURY-TEIXEIRA; BRONZO, 2010, p.38).

Thus, when analysing these impacts, we must observe the dependence of these populations on their environment and how the 'health' of this environment determines the rhythm and social organisation of the communities. In this sense, we understand that changes in these environments resonate in

individuals' living conditions and organisational structure. The vulnerability from the oil spill in the territories affects complex and deep dimensions not limited to undersized fish or one-off environmental issues. However, it makes lifestyle, or the most significant expression of the subject in the territory where it reproduces socially, vulnerable (BRANDÃO, 2010; BREILH, 2013).

Grasping the essence of the territory is based on Santos (1999), who understands territory as the expression of courage, authenticity, and strength to promote protective tools against destructive processes:

> The territory has to be understood as the land space employed, not the territory itself. The territory used is the ground plus the identity. Identity is the feeling of belonging to what belongs to us. The territory is the foundation of work, the place of residence, the material and spiritual exchanges, and the exercise of life (SANTOS, 1999, p. 8).

From this correlation, traditional fishing communities achieve autonomy vis-à-vis their social and work processes. However, it can often be traversed by social and environmental conflicts, such as those promoted by shrimp farming, for example; by the advance of neo-extractivism, a central model in the Brazilian economy; and by disasters and environmental injustice, relativising their autonomy (BRANDÃO, 2010; RIGOTTO *et al*., 2018). Such processes are subsumed to other overdetermined events that should be considered when observing the processes established in the territories, as they influence the health condition and recovery from disasters such as oil spills.

Disasters escalate the socio-environmental vulnerability of populations that have historically experienced vulnerability. They highlight the limited ability to understand health under the particularities of individuals and their social groups, as of traditional communities that live under specific circumstances. As the individual is formed by biological singularities, perennial to his condition and political, socioeconomic, cultural, and spiritual factors, the construction of what is health begins with intersubjectivities created in a communal and then societal construction (SAMAJA, 2000).

Therefore, health is a multifaceted condition influenced and determined by different markers and social processes that challenge subjects and groups. The implication of the systemic approach by analysing the social determination of health in different cultural groups becomes increasingly necessary to familiarise oneself with individuals' social and cultural universe when confronting different contexts, experiences, and values (CONCONE, 2003).

The National Policy for the Comprehensive Health of the Rural, Forest, and Water Population (PNSIPCFA) shows how much progress still needs to be made in meeting the needs of these people. The policy understands and alerts us to diverse communities in the rural environment and sheds light on the various needs that emerge from this close relationship with the land, forests, fields, and, in this case, waters (BRASIL, 2014).

Considering this, we observe that such necessities surface from work relationships built and perpetuated in this type of environment and the environmental transformations imposed by the productive model – that affect the health of communities and compromise a range of knowledge and practices that shape their identity and sovereignty (BRASIL, 2014). Such injustice results in several processes that make life vulnerable in its social, economic, cultural, and spiritual aspects, causing illness and, often, death (PORTO, 2014).

5 FINAL CONSIDERATIONS

Understanding health, whether to preserve a healthy state or manage illness processes, must be thought of from a multidimensional, systemic, and convergent perspective, without overcoming the particular reality of each community or people, due to the insurmountable and complex barrier of totality, which shelters a multifaceted life in its status quo, inherent to the social history of these individuals.

Thus, it assumes that the oil spill impacts are pondered from the complex reproduction of life and health processes, intrinsic to the construction of meanings and feelings in these communities, subjective and divergent from developmental and globalising ideas. Furthermore, more than strictly technical methods focusing on body intervention in a cause-effect rationale is required, and a fragmented health action can exacerbate existing vulnerabilities.

Disregarding individuals as 'multisystemic' beings is stealing the existential life dynamics, isolating them from socio-environmental processes, and addressing health as a static element, not a process of compensations and experiences. Individuals' historical path, relationship with nature, spirituality, and cosmovision underpin how they experience the world and conceive their understanding of health.

Finally, we should consider in this paper this textual genre's limitations. We reiterate that the text considers and prioritises the theoretical postulates advocated by the authors and is, to a certain extent, the defence of a thesis based on expertise in Health, Environment, and Work.

REFERENCES

ACSELRAD, H. Ambientalização das lutas sociais: o caso do movimento por justiça ambiental. **Estudos Avançados**, São Paulo, v. 24, n. 68, p. 103-119, 2010. Available at: http://www.scielo.br/scielo.php?script= sci_arttext & pid=S0103-40142010000100010 & lng= en\ nrm=iso.

ACSELRAD, H. O conhecimento do ambiente e o ambiente do conhecimento: anotações sobre a conjuntura do debate sobre vulnerabilidade. **Em Pauta**, v. 11, n. 32, p. 115-129, 2017.

ALMEIDA FILHO, N. Modelagem da pandemia da Covid-19 como objeto complexo (notas samajianas). **Estudos Avançados**, v. 34, n. 99, p. 97-118, 2020. Available at: http://dx.doi.org/10.1590/s0103-4014.2020.3499.007

ARAÚJO, I. M. M.; OLIVEIRA, Â. G. R. C. Interfaces entre a saúde coletiva e a ecologia política: vulnerabilização, território e metabolismo social. **Saúde em Debate**, v. 41, n. 2, p. 276-286, 2017. Available at: https://dx.doi.org/10.1590/0103-11042017s223

ARAÚJO, M. E.; RAMALHO, C. W. N.; MELO, P. W. Pescadores artesanais, consumidores e meio ambiente: consequências imediatas do vazamento de petróleo no Estado de Pernambuco, Nordeste do Brasil. **Cad. Saúde Pública**, Rio de Janeiro, v. 36, n. 1. 2020. Available at: https://doi.org/10.1590/0102-311X00230319

BRANDÃO, C. R. A comunidade tradicional. In: COSTA, J. B. A.; LUZ, C. (Org.). **Cerrados, Gerais, Sertão**: comunidades tradicionais dos sertões Roseanos. Montes Claros: Intermeios, p. 347-361, 2010. Available at: http://nupaub.fflch.usp.br/sites/nupaub.fflch.usp.br/files/a%20comunidade%20trad160.pdf

BRASIL. **Lei n. 10.779, de 25 de novembro de 2003**. Dispõe sobre a concessão do benefício de seguro-desemprego, durante o período de defeso, ao pescador profissional que exerce a atividade pesqueira de forma artesanal. Available at: http://www.planalto.gov.br/ccivil_03/leis/2003/l10.779.htm. Accessed on: 12 ago. 2022.

BRASIL. Lei n. 11.959, de 29 de junho de 2009. Dispõe sobre a política nacional de desenvolvimento sustentável da aquicultura e da pesca e dá outras providências. **Diário Oficial da República Federativa do Brasil**, Brasília, DF, n. 122, p.1-3, 30/06/2009. Seção 1.

BRASIL. **Portaria nº 2.311, de 23 de outubro de 2014**. Altera a Portaria nº 2.866/GM/MS, de 2 de dezembro de 2011, que institui, no âmbito do Sistema Único de Saúde (SUS), a Política Nacional de Saúde Integral das Populações do Campo e da Floresta (PNSIPCF). 2014.

BREILH, J. La determinación social de la salud como herramienta de transformación hacia una nueva salud pública (salud colectiva). **Revista Faculdad Nacional de Salud Pública**, v. 31, n. supl 1, p. 13–27, 2013. Available at: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-386X2013000400002

CARMO, E. H.; TEIXEIRA, M. G. Desastres tecnológicos e emergências de saúde pública: o caso do derramamento de óleo no litoral do Brasil. **Cadernos de Saúde Pública** [online]. 2020, v. 36, n. 2 [Acessado em 12 ago. 2022], e00234419. Available at: https://doi.org/10.1590/0102-311X00234419 Epub 31 Jan 2020. ISSN 1678-4464.

CONCONE, M. H. V. B. Os Sentidos da Saúde: uma abordagem despretensiosa. In: GOLDENBERG, P. (Org.) **O Clássico e o Novo**: tendências, objetos e abordagens em ciências sociais e saúde. Rio de Janeiro: Editora Fiocruz, 2003.

CONSELHO PASTORAL DA PESCA. **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil**: relatório 2021. BARROS, S.; MEDEIROS, A.; GOMES, E. B. (Org.) 2nd ed. Olinda, 2021. ISBN 978-65-992464-5-6.

CROISANT, S.; SULLIVAN, J. Studying the Human Health and Ecological Impacts of the Deep Water Horizon Oil Spill Disaster: introduction to this special issue of New Solutions. **New Solutions: A Journal of Environmental and Occupational Health Policy**, v. 28, n. 3, p. 410–415, 2018. Available at: http://journals.sagepub.com/doi/10.1177/1048291118795691.

CUNHA, A. M. **A colonização e o desenvolvimento capitalista do Brasil**. 2012. Available at: http://www.ufrgs.br/decon/publionline/textosdidaticos/textodid14.pdf.

D'ALMEIDA, A. L. **Indústria do petróleo no Brasil e no mundo**: formação, desenvolvimento e ambiência atual. Editora Blucher, 2015.

D'ALMEIDA, A. L. **O fim da era do petróleo está próximo?** Fundação Getúlio Vargas. Energia. 2019.

DIEGUES, A. C. S. **Pescadores, camponeses e trabalhadores do mar**. São Paulo: Ática, 1983.

DOMINGUES, R. C. C.; SANTOS, M. O. S.; GURGEL, I. G. D. A vulneração socioambiental advinda do complexo industrial portuário de Suape: a perspectiva dos moradores da Ilha de Tatuoca–Ipojuca/PE. **Tempus Actas de Saúde Coletiva**, v. 8, n. 2, p. 69-91, 2014. Available at: https://doi.org/10.18569/tempus.v8i2.1513

EL-SAYED, A.; KAMEL, M. Climatic changes and their role in emergence and re-emergence of diseases. **Environ Sci Pollut Res Int**, v. 27, n. 18, p. 22336-22352, 2020. DOI 10.1007/s11356-020-08896-w

EPE. Empresa de Pesquisa Energética. **Balanço Energético Nacional 2022**. Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-675/topico-631/BEN_S%C3%ADntese_2022_PT.pdf

FALCÃO, I. R. *et al*. Fatores associados com os distúrbios musculoesqueléticos em pescadoras artesanais/marisqueiras em Saubara, Bahia, Brasil. **Ciência & Saúde Coletiva** [online]. 2019, v. 24, n. 7 [Acessado em 12 ago. 2022], p. 2557-2568. Epub 22 Jul 2019. ISSN 1678-4561. Available at: https://doi.org/10.1590/1413-81232018247.19712017.

FAO. 2020. **The State of World Fisheries and Aquaculture 2020**. Sustainability in action. Rome. Available at: https://doi.org/10.4060/ca9229en.

FLEURY-TEIXEIRA, P.; BRONZO, C. **Determinação social da saúde e reforma sanitária**. In: NOGUEIRA, R. P. (org.). Determinação social da saúde e política. Rio de Janeiro: Cebes, 2010.

FREITAS, M. I. C.; CUNHA, L. Cartografia da vulnerabilidade socioambiental: convergências e divergências a partir de algumas experiências em Portugal e no Brasil. **Urbe. Revista Brasileira de Gestão Urbana**, v. 5, n. 1, p. 15-31, 2013. Available at: https://dx.doi.org/10.7213/urbe.7783.

GASPAR, R. C. A trajetória da economia mundial: da recuperação do pós-guerra aos desafios contemporâneos. **Cadernos Metrópole** [online]. 2015, v. 17, n. 33 [Acessado em 25 jul. 2022] p. 265-296. Available at: https://doi.org/10.1590/2236-9996.2015-3312

GOLDSTEIN, B. D.; OSOFSKY, H. J.; LICHTVELD, M. Y. The Gulf Oil Spill. **New England Journal of Medicine**, v. 364, n. 14, p. 1334–1348, 2011. Available at: http://www.nejm.org/doi/abs/10.1056/NEJMra1007197

GUIMARÃES, S. R.; ANDRADE, M. R. F. L. Pesca artesanal: reflexões sobre políticas públicas na Colônia de Pescadores Z-33 em Porto Jatobá, Pernambuco. **Interações** (Campo Grande), v. 21, p. 347-361, 2020. Available at: https://doi.org/10.20435/inter.v21i2.2167

GURGEL, A. M. *et al*. Framework dos cenários de risco no contexto da implantação de uma refinaria de petróleo em Pernambuco. **Ciência & Saúde Coletiva**, v. 14, n. 6, p. 2027–2038, 2009. Available at: https://doi.org/10.1590/S1413-81232009000600010

GURGEL, A. M. *et al*. Uso do coque verde de petróleo como matriz energética e potenciais danos à saúde e ao ambiente. In: SANTOS, M. O. S.; GURGEL, A. M.; GURGEL, I. G. D. **Conflitos e injustiças na instalação de refinarias**: os caminhos sinuosos de Suape, Pernambuco. Recife: Ed. UFPE, p. 119-146, 2019.

GURGEL, A. M. **Uso do coque verde de petróleo como matriz energética em Pernambuco e a perspectiva da vigilância em saúde**: estudo de caso no Complexo Industrial Portuário de Suape. Dissertação (Mestrado Acadêmico em Saúde Pública) – Centro de Pesquisas Aggeu Magalhães, Fundação Oswaldo Cruz. Recife, p. 159. 2011.

LAFFON, B.; VALDIGLESIAS, V.; PASÁRO, E. Effects of Exposure to Oil Spills on Human Health: updated review article. **Journal of Toxicology and Environmental Health Part B**: critical reviews, v. 19, n. 03, p. 1-24, 2016. Available at: https://www.researchgate.net/publication/303511825_Effects_of_Exposure_to_Oil_Spills_on_Human_Health_Updated_Review.

MARTINEZ-ALIER, J. *et al*. (Forthcoming) Is there a global environmental justice movement? **Journal of Peasant Studies**, v. 43, n. 3, p. 731-755, 2016. Available at: https://doi.org/10.1080/03066150.2016.1141198

MATTOS, S. M. G.; WOJCIECHOWSKI, M. J.; GANDINI, F. C. **Iluminando as Capturas Ocultas da Pesca Artesanal Costeira no Brasil**: um estudo de caso. Relatório Executivo. Food and Agriculture Organization of the United Nations (FAO), the WorldFish, and the University of Duke (Orgs.).

MENDONÇA, J. T.; MATTOS, S. M. G. Panorama da política pesqueira no Brasil em 2020. In: **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil**: relatório. Conselho Pastoral dos Pescadores. Available at: http://www.cppnacional.org.br/publicacao/relat%C3%B3rio-dos- conflitos-socioambientais-e-viola%C3%A7%C3%B5es-de-direitos-humanos%C2%A0em%C2%A0comunidades. 2021.

MESQUITA, B.; QUINAMO, T. **Impactos socioeconômicos e ambientais da contaminação por petróleo nas praias do litoral da Região Nordeste do Brasil**. Recife. p. 41. 2020.

MOREIRA, J. F. M. **Acidentes na indústria de petróleo e seus impactos na segurança operacional e preservação ambiental**. Trabalho de conclusão (Bacharelado em Engenharia do Petróleo) – Universidade Federal Fluminense. Niterói, p.100. 2017.

NASCIMENTO, A. M. S. **A relação trabalho-saúde das marisqueiras na atividade da pesca artesanal**: revisão integrativa da literatura. 2022. 70 folhas. Trabalho de Conclusão de Curso (Graduação em Biomedicina) – Universidade Federal de Pernambuco, Recife, 2022.

OLIVEIRA, O. M. B. A.; SILVA, V. L. O Processo de Industrialização do Setor Pesqueiro e a Desestruturação da Pesca Artesanal no Brasil a partir do Código de Pesca de 1967. **Sequência**, p. 329-357, 2012. Available at: http://dx.doi.org/10.5007/2177-7055.2012v33n65p329

PATZ, J. A. *et al*. Climate change: challenges and opportunities for global health. **JAMA**, v. 312, n. 15, p. 1565-1580. 2014. DOI 10.1001/jama.2014.13186

PAULA, C. Q. Impactos ambientais na pesca artesanal brasileira: uma interpretação geográfica. **PerCursos**, v. 19, n. 41, p. 79-106, 2018. Available at: https://doi.org/10.5965/1984724619412018079

PENA, P. G. L.; GOMEZ, C. M. Saúde dos pescadores artesanais e desafios para a Vigilância em Saúde do Trabalhador. **Ciência & Saúde Coletiva**, v. 19, p. 4689-4698, 2014. Available at: https://doi.org/10.1590/1413-812320141912.13162014

PENA, P. G. L. *et al*. Derramamento de óleo bruto na costa brasileira em 2019: emergência em saúde pública em questão. **Cadernos de Saúde Pública** [online]. v. 36, n. 3. Available at: https://doi.org/10.1590/0102-311XER231019. ISSN 1678-4464. Accessed on: 12 ago. 2022.

PENA, P. G. L.; GOMEZ, C. M. Health of subsistence fishermen and challenges for Occupational Health Surveillance. **Ciência & Saúde Coletiva** [online]. 2014, v. 19, n. 12, p. 4689-4698. ISSN 1678-4561. Available at: https://doi.org/10.1590/1413-812320141912.13162014

PENA, P. G. L.; MARTINS, V.; RÊGO, R. F. Por uma política para a saúde do trabalhador não assalariado: o caso dos pescadores artesanais e das marisqueiras. **Rev. Bras. Saúde Ocup**, v. 38, n. 127, p. 57-68. 2013. Available at: https://doi.org/10.1590/S0303-76572013000100009

PÉREZ, M. S. **Re-existências dos camponeses/as do que hoje é Suape**: justiça territorial, pós-desenvolvimento e descolonialidade pela vida. 2016. Tese (Doutorado Acadêmico em Geografia) – Universidade Federal de Pernambuco, Recife, 2016.

PESSOA, V. M.; ALMEIDA, M. M.; CARNEIRO, F. F. Como garantir o direito à saúde para as populações do campo, da floresta e das águas no Brasil? **Saúde em Debate**, v. 42, p. 302-314, 2018. Available at: https://doi.org/10.1590/0103-11042018S120

PORTO, M. F. S.; ROCHA, D. F.; FINAMORE, R. Saúde coletiva, território e conflitos ambientais: bases para um enfoque socioambiental crítico. **Ciência & Saúde Coletiva**, v. 19, n.10, p. 4071-4080, 2014. Available at: https://doi.org/10.1590/1413-812320141910.09062014

PORTO, M. F. S. Complexidade, processos de vulnerabilização e justiça ambiental: um ensaio de epistemologia política. **Revista Crítica de Ciências Sociais**, v. 93, p. 31-58, jun 2011. Available at: https://doi.org/10.4000/rccs.133

RAMALHO, C. W. N.; SANTOS, S. A. O cotidiano das comunidades pesqueiras: entre o petróleo e o novo coronavírus. *In:* **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil. 2021**. BARROS, S.; MEDEIROS, A.; GOMES, E. B. (Orgs). 2nd ed. Olinda. Conselho Pastoral dos Pescadores. ISBN 978-65-992464-5-6.

REDDY, C. M. *et al*. **Synergy of Analytical Approaches Enables a Robust Assessment of the Brazil Mystery Oil Spill**. 2022. Energy & Fuels Article ASAP. DOI 10.1021/acs.energyfuels.2c00656

RÊGO, R. F. R. *et al*. Vigilância em saúde do trabalhador da pesca artesanal na Baía de Todos os Santos: da invisibilidade à proposição de políticas públicas para o Sistema Único de Saúde (SUS). **Revista Brasileira de Saúde Ocupacional**, v. 43, p. 1-9, 2018. Available at: https://doi.org/10.1590/2317-6369000003618

RIBEIRO, H. Impactos da Exploração do Petróleo na Saúde Humana. **Revista USP**, v. 1, n. 95, p. 61-71, 2012. Available at: http://www.revistas.usp.br/revusp/article/view/52239

RIGOTTO, R. M.; AGUIAR, A. C. P.; RIBEIRO, L. A. D. **Tramas para a Justiça Ambiental**: diálogo de saberes e práxis emancipatórias. Fortaleza: Edições UFC, 2018.

SAMAJA, J. **Reprodução Social e a Saúde**. Salvador: Casa da Qualidade Editora, 2000.

SANTOS, M. O. S. *et al*. **Oil in Northeast Brazil**: mapping conflicts and impacts of the biggest disaster on the country's coast. 2022. Anais da Academia Brasileira de Ciências [online]. 2022. Available at: https://doi.org/10.1590/0001-3765202220220014

SANTOS, M. O. S.; GURGEL, A. M.; GURGEL, I. G. D. **Conflitos e injustiças na instalação de refinarias**: os caminhos sinuosos de Suape, Pernambuco. Ed. Universitária da UFPE. Recife, 2019.

SANTOS, M. O. S. **Vulneração e injustiças ambientais na determinação social da saúde no território de Suape, Pernambuco/Brasil**. 2017. Tese (Doutorado Acadêmico em Saúde Pública) – Instituto Aggeu Magalhães, Fundação Oswaldo Cruz. Available at: https://www.arca.fiocruz.br/handle/icict/28046.

SANTOS, M. **O dinheiro e o território**. 1st ed. Rio de Janeiro: GEOgraphia,1999. 7-13 p.

SILVA, A. P. Pesca artesanal brasileira: aspectos conceituais, históricos, institucionais e prospectivos. **Embrapa Pesca e Aquicultura**. Boletim de Pesquisa e Desenvolvimento, 2014.

SILVA, J. M. da. **A perspectiva da saúde nos Estudos de Impacto Ambiental de megaprojetos de infraestrutura no Brasil**: uma análise bioética e epistemológica. 2017. Tese (Doutorado em Saúde Pública) – Instituto Aggeu Magalhães, Fundação Oswaldo Cruz. Recife, 2017.

SILVA, F. R. da *et al*. Oil Spill and Socioeconomic Vulnerability in Marine Protected Areas. **Frontiers in Marine Science**, p. 718, 2022. Available at: https://doi.org/10.1590/0102-311X00234419.

SOARES, E. C. *et al*. Impacto do petróleo no meio ambiente e nos organismos aquáticos nas costas dos estados de Alagoas e Sergipe, Brasil: uma avaliação preliminar. **Touro Poluente Mar**, 2021. Available at: 10.1016/j.marpolbul.2021.112723.

SOARES, M. O. *et al*. Oil spill in South Atlantic (Brazil): environmental and governmental disaster. **Marine Policy**, v. 115, 103879. 2020. Available at: https://doi.org/10.1016/j.marpol.2020.103879

SOARES, M. O.; TEIXEIRA, C. E. P.; BEZERRA, L. E. A. O derramamento de óleo mais extenso registrado nos oceanos tropicais (Brasil): o balanço de um desastre. **Environmental Science and Pollution Research**, v. 29, n. 13, p. 19869-19877. 2022. Available at: https://doi.org/10.1007/s11356-022-18710-4.

TAKESHITA, R.; BURSIAN, S. J.; COLEGROVE, K. M. A review of the toxicology of oil in vertebrates: what we have learned following the Deepwater Horizon oil spill. **Journal of Toxicology and Environmental Health, Part B**, v. 24, n. 8, p. 355-394, 2021. Available at: https://doi.org/10.1080/10937404.2021.1975182

VIGLIO, J. E. *et al*. Narrativas científicas sobre petróleo e mudanças do clima e suas reverberações na política climática brasileira. **Sociologias** [online], v. 21, n. 51, p. 124-158. Available at: https://doi.org/10.1590/15174522-0215105. 2019.

Determinação social da saúde de trabalhadores da pesca artesanal em desastres com petróleo

Social determination of health of small-scale fishing workers in oil disasters

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RESUMO

Este ensaio apresenta reflexões sobre o modelo por petróleo dependente e sua relação com os processos de vulnerabilização na saúde das comunidades da pesca artesanal sob a perspectiva da determinação social da saúde. Estruturou-se em três eixos de análise: a caracterização do processo de dependência dos combustíveis fósseis pela indústria e as consequências para as populações dos territórios afetados; o desastre-crime do petróleo ocorrido no Brasil a partir de 2019 e, por fim, à luz da concepção de Breilh (2013), a caracterização do processo da determinação social da saúde nos territórios vulnerabilizados e afetados por esses desastres. A noção de saúde dissociada das construções sociais, culturais, econômicas, espirituais e políticas conforma um modelo insuficiente na análise do processo saúde-doença, identificando um ser fragmentado e desconsiderando a sobreposição de camadas "inorgânicas" que suprime e reorganiza a existência.

Palavras-chave: Poluição por petróleo. Vulnerabilidade a desastres. Saúde ambiental. Processo saúde-doença.

ABSTRACT

This essay reflects on the oil-dependent model and its relationship with vulnerability in the health of small-scale fishing communities from the Social Determination of Health perspective. Three analysis axes were structured as follows: characterising the industry's dependence on fossil fuels and the consequences for the populations of the affected territories; the Brazilian oil disaster crime in 2019; and finally, considering Breilh's conception (2013), characterising the social determination of health in the vulnerable territories affected by these disasters. The notion of health dissociated from social, cultural, economic, spiritual, and political constructions represents an insufficient model for analysing the health-disease process, identifying a fragmented being and disregarding the overlapping of "inorganic" layers that suppresses and reorganises existence.

Keywords: Petroleum pollution. Disaster vulnerability. Environmental health. Health-Disease Process.

1 INTRODUÇÃO

Modelos energéticos dependentes de matrizes não renováveis, como o petróleo, têm papel central na crise climática global e são determinantes para a ocorrência de eventos climáticos extremos. Esses modelos também contribuem para o avanço do desmatamento, a destruição de biomas, a ocorrência de doenças e a insegurança alimentar e nutricional (EL-SAYED; KAMEL, 2020; PATZ *et al*., 2014). Embora a associação entre o consumo de combustíveis fósseis, como o petróleo, e a crise climática seja reconhecida, a instalação de polos petroquímicos no mundo é frequente e suscita narrativas distintas para a transição de fontes de energia renováveis, sobretudo em países em desenvolvimento (VIGLIO *et al*., 2019).

Observam-se diferentes níveis e tipos de exposição humana aos poluentes, especialmente de trabalhadores dessa cadeia produtiva, além de contaminação da fauna e flora e desastres nas atividades produtivas relacionadas à extração, refino e demais operações envolvendo o petróleo. Esses eventos provocam diversos processos de vulnerabilização socioambiental, com comprometimento de aspectos materiais e simbólicos e reflexo na saúde das pessoas, principalmente em situação de vulnerabilidade (GURGEL, 2011; SANTOS *et al*., 2019; SOARES *et al*., 2021).

Desastres como derramamentos de petróleo constituem um problema sistêmico e podem provocar danos ecológicos e socioeconômicos com implicações sobre os ecossistemas e a saúde das populações humanas que vivem no entorno dos empreendimentos ou em áreas costeiras, como as comunidades da pesca artesanal, e representam um preocupante problema ambiental e de emergência em saúde pública (CARMO; TEIXEIRA, 2020; GURGEL, 2011; PENA *et al*., 2020; SANTOS, 2019; SILVA *et al*., 2022).

Estudos a partir de perspectivas complexas e sistêmicas sobre o processo de saúde-doença de comunidades afetadas podem contribuir com alternativas para melhoria de vida nas comunidades afetadas por esses desastres. Os aspectos teórico-conceituais da determinação social da saúde latino-americana demonstram ser um caminho para a compreensão dos danos e agravos de forma complexa e contribuição para os planos de ação nesses contextos.

Este ensaio tem por objetivo apresentar reflexões sobre o modelo por petróleo dependente e sua relação com os processos de vulnerabilização na saúde das comunidades da pesca artesanal sob a perspectiva da determinação social da saúde. O ensaio foi estruturado na perspectiva histórica e dialética da determinação social da saúde proposta pelo epidemiologista Jaime Breilh (2013) para a compreensão da saúde coletiva.

A partir da literatura científica identificada, definiram-se três eixos de análise: inicialmente, caracterizam-se o processo de dependência dos combustíveis fósseis pela indústria, particularmente no Brasil, e as consequências para as populações nos territórios afetados. Em seguida, destaca-se o desastre-crime do petróleo ocorrido no Brasil em 2019 e as repercussões nas comunidades da pesca artesanal, considerando-se questões relacionadas à gestão da pesca artesanal, às ações antrópicas no ambiente, e aos danos à saúde de pescadores artesanais. Por fim, à luz da concepção de Breilh (2013), caracteriza-se o processo da determinação social da saúde nesses territórios vulnerabilizados e afetados por tais desastres.

2 TRANSFORMAÇÕES ESTRUTURAIS: A INDÚSTRIA DEPENDENTE DO PETRÓLEO

A grande valorização do petróleo advém principalmente de três grandes marcos na década de 1970: a) os Estados Unidos perdem a sua centralidade na produção do petróleo, passando a dividir espaço com o Oriente Médio; b) a elevação do preço do barril do petróleo em 1973, quando quase triplicou de valor e passou a ser utilizado como instrumento de disputa no Oriente Médio, que detém grande parte das reservas de petróleo de boa qualidade no mundo; e c) a segunda crise do petróleo em 1979, quando houve o corte na exportação pelo segundo maior produtor da época, o Irã (D'ALMEIDA, 2015, 2019; GASPAR, 2015). Tais fatos impulsionaram a extração desse recurso finito, sustentando diversos processos de vulnerabilização que refletem na vida dos sujeitos e dos territórios onde os empreendimentos são implantados. Importante considerar que a vulnerabilização dos territórios tem origem nas históricas relações sociais, e nos processos que vão além da dimensão biológica, marcadas pela injustiça ambiental e social (BREILH, 2013; GURGEL, 2011, 2019; PORTO, 2014; SANTOS, 2019).

No Brasil, entre os combustíveis fósseis, gás natural, petróleo e carvão mineral, utilizados na matriz energética, o petróleo ocupa o primeiro lugar entre as principais fontes. Em contrapartida, a energia solar, a energia hidráulica, a biomassa e a energia eólica são fontes de energia renováveis que representam cerca de 44,7% da energia utilizada no Brasil. Destaca-se o uso de grandes hidrelétricas, eólicas e derivados da cana-de-açúcar, que também podem desenvolver riscos e agravos à saúde e ao ambiente, embora o petróleo e seus derivados permaneçam como estruturantes da matriz energética no Brasil (EPE, 2022; SANTOS, 2019).

Diversos estados brasileiros, especialmente na Região Nordeste, têm ampliado seu polo petroquímico por meio da implantação de indústrias e complexos portuários, como a Refinaria Abreu e Lima (Rnest) e a Petroquímica Suape, em Pernambuco; a Refinaria Potiguar Clara Camarão, no Rio Grande do Norte; a ampliação do polo petroquímico de Camaçari, na Bahia, e as Refinarias Premium I e Premium II, que seriam instaladas respectivamente no Maranhão e no Ceará, mas que tiveram suas obras canceladas em 2015 (GURGEL, 2011; PÉREZ, 2016; SANTOS, 2017; SILVA, 2017).

O aumento da instalação dessas refinarias é também inversamente proporcional à lógica de organização do território onde essas refinarias são construídas, produzindo processos de vulnerabilização, intensificação de conflitos e injustiças ambientais, contaminação ambiental e exposição química que compromete a saúde e a qualidade de vida das populações (DOMINGUES *et al*., 2014; SANTOS, 2017; SANTOS *et al*., 2022).

Os desastres associados à cadeia do petróleo podem prejudicar, de forma irreparável, os ecossistemas marinhos e as pessoas que dependem diretamente dele (PENA *et al*., 2020; SILVA *et al*., 2022). Um dos aspectos mais críticos relacionados à implantação de grandes empreendimentos como esses é o ocultamento dos problemas e das mudanças que seus processos de construção e operação trazem para o território onde as pessoas vivem e trabalham, como a violação de direitos humanos e as injustiças socioambientais (CPP, 2021; SANTOS, 2011, 2017).

Outros efeitos da exposição direta ao petróleo e seus derivados são as doenças respiratórias, neurológicas, hepáticas, renais, endócrinas, hematológicas e outras (LAFFON, 2016). Os efeitos fisiológicos podem ser agudos ou crônicos, não existindo um limiar seguro de exposição para determinados efeitos, como o câncer (CROISANT; SULLIVAN, 2018; RIBEIRO, 2012).

A perda do território pesqueiro, a devastação ambiental e a precariedade na pesca artesanal são exemplos de grandes violações de direitos humanos e ecológicos que demarcam a realidade vivenciada por essas comunidades no Brasil. O atual momento histórico, marcado por profundas crises ecológicas, econômicas e sociais, exige repensar o modelo de produção de petróleo dependente à luz dos limites da própria natureza (MARTINEZ-ALIER *et al*., 2016).

No Brasil, em agosto de 2019, grandes manchas de óleo foram registradas em praias dos estados do litoral nordestino, alcançando também o Sudeste do país. No total, foram afetados 11 estados, 130 municípios, 1.009 localidades e mais de 3.000 km do litoral da costa brasileira, configurando-se como o maior desastre em extensão no Brasil. Estima-se que foram coletadas mais de 5,3 mil toneladas de resíduos de petróleo das praias (MESQUITA; QUINAMO, 2020; REDDY, 2022; SOARES, 2022).

Entre as populações mais afetadas estão os pescadores artesanais que tiveram seus territórios diretamente atingidos pelo petróleo, afetando a vida presente no mangue, no mar e nas praias. No período, a mídia exerceu um papel de desinformação e invisibilização, anunciando de forma arbitrária a contaminação de todos os peixes e mariscos do litoral, o que contribuiu para o processo de vulnerabilização em razão da brusca redução na comercialização de peixes e mariscos, acarretando extensos prejuízos financeiros aos pescadores (PENA *et al*., 2020; SANTOS *et al*., 2022).

Identificou-se, ainda, o sofrimento mental em decorrência da situação vivenciada, sobretudo no que diz respeito à falta de trabalho e à perda de renda. Em desastres semelhantes, como foi o caso da explosão da plataforma Deepwater Horizon no Golfo do México, o derramamento de petróleo representou uma questão de segurança nacional relacionada ao consumo de pescados, contribuindo para o sofrimento mental e oneração do trabalho, saúde e dos modos de vida dessas populações (GOLDSTEIN *et al*., 2011; MOREIRA, 2017).

3 COMUNIDADES DA PESCA ARTESANAL E REPERCUSSÕES DO DESASTRE-CRIME DO PETRÓLEO

Os povos das águas possuem saberes desenvolvidos a partir da utilização, observação, convivência e dependência dos recursos naturais encontrados nos ambientes marinhos e continental, conforme preconiza a Política Nacional de Saúde Integral das Populações do Campo, da Floresta e das Águas, direcionada à proteção e qualificação do acesso à saúde dessas populações no Brasil, “são povos e comunidades com modos de vida, produção e reprodução social relacionados predominantemente com os ambientes aquáticos", como pescadores artesanais (BRASIL, 2014, art. 2o).

Os pescadores artesanais são caracterizados pelas atividades da pesca em pequena escala, desembarcados ou em pequenas embarcações, para a captura de diferentes espécies de peixes, moluscos, crustáceos, entre outros, para comercialização por meio de compradores diretos, atravessadores e venda em feiras e mercados públicos (RÊGO *et al*., 2018). Além da comercialização, a pesca assume uma dimensão afetiva e de consumo alimentar das populações costeiras.

A comunidade pesqueira, bem como outros povos e comunidades tradicionais, faz parte de um conjunto específico de populações que reproduzem seus modos de vida tradicionais, caracterizados por uma autonomia relativa (BRANDÃO, 2010). Os pescadores artesanais possuem seu modo de vida atrelado às condições produtivas saudáveis e sustentáveis, no sentido de subsistência do ambiente natural – marés, rios, estuários, manguezais, entre outros.

O Brasil é um dos maiores produtores de pescado da América Latina, ocupando a 18a posição no ranking mundial. Essa posição é estimada, uma vez que o Brasil não tem disponibilizado dados oficiais de produção pesqueira desde 2014 (FAO, 2020, p. 21). Assim, apesar da importância cultural e produtiva dessas populações, o cadastro dos trabalhadores artesanais da pesca realizado pelo governo brasileiro está desatualizado. Além disso, os dados existentes não seguem um padrão de organização, dificultando a obtenção de informações fidedignas (MENDONÇA; MATTOS, 2021).

Entre as questões enfrentadas pelos pescadores artesanais que impactam diretamente as condições de trabalho e de vida, destacam-se três: 1) problemas no campo da gestão política da pesca artesanal; 2) problemas no ambiente que são de origem antrópica; 3) danos à saúde provocados pela atividade laboral da pesca artesanal.

No campo da política e da gestão pública, a regulação da atividade da pesca artesanal iniciou-se a partir da formação organizativa de pescadores em colônias, ou seja, em organizações sociais de representação da atividade pesqueira artesanal, que atualmente são responsáveis pelo reconhecimento da profissionalização dos indivíduos (OLIVEIRA; SILVA, 2012). Após o período de criação de colônias de maneira espontânea entre os pescadores, a governança da atividade de pesca passou por mais de 100 anos de instabilidade, entre os Ministérios da Marinha e da Agricultura.

Nesse ínterim, houve um importante incremento no número de colônias em todo o território nacional, que conta com aproximadamente 800 unidades desse tipo de estabelecimento, como consequência de nítida intenção da Marinha em fomentar a militarização via promoção da defesa nacional por vias marítimas e, especialmente, impulsionar o desenvolvimento econômico do país, já que os pescadores estariam em pontos estratégicos no mar (SILVA, 2014). A modernização das práticas produtivas nacionais, principalmente a agricultura e a pesca, faz parte do ideário de mecanização das atividades para o "desenvolvimento econômico da nação" (CUNHA, 2012).

A modernização no caso da pesca artesanal relacionou-se com o incentivo à industrialização do setor, sobretudo apoiado em ações políticas, como a criação do Código da Pesca em 1967, que regulamenta as atividades pesqueiras. O Brasil realizou o fomento à pesca industrial a partir de incentivos financeiros, isenção de determinados impostos sobre produtos e maquinário, enquanto negligenciava a pesca artesanal. Em consequência, foi instaurado um processo de descaracterização da pesca artesanal, vulnerabilizando a identidade e a reprodução social dessas comunidades. Alguns autores defendem que o aumento considerável da pesca industrial pode influenciar o esgotamento de diferentes espécies de peixes, prejudicando principalmente pescadores artesanais que pescam em pequena escala (GUIMARÃES; LEITÃO, 2020).

Em avanços no campo legislativo, a Lei nº 10.779/2003 estabeleceu no Brasil uma regulamentação jurídica direcionada à garantia de direitos sociais para a pesca artesanal, com a concessão de benefícios trabalhistas, como o seguro-desemprego no período de reprodução de espécies, quando a pesca não é permitida, em razão da preservação das espécies (BRASIL, 2003). A Lei de Pesca nº 11.959/2009,

embora sem oferecer atualizações nos direitos sociais, legaliza a atividade da pesca artesanal, permitindo também a disponibilização de empréstimos com baixas taxas de juros para manutenção das operações desse setor (BRASIL, 2009). Com isso, Oliveira e Silva (2012) ressaltam a importância de uma regulamentação jurídica, ainda que tardia, sobre a pesca artesanal:

> A regulamentação da atividade possibilita o reconhecimento profissional dos trabalhadores. Assim, o pescador passa a resguardar para si todos os direitos advindos das atividades laborais, especialmente em relação aos benefícios previdenciários. E, por último, mas não menos importante, a regulamentação serve como maneira de afirmar políticas públicas de estímulo a atividades comunitárias e não industriais, atividades negligenciadas e, inclusive, suprimidas pelos regimes autoritários brasileiros (OLIVEIRA; SILVA, 2012, p.10).

Além das garantias trabalhistas quanto à regulamentação da profissão da pesca, os ordenamentos jurídicos devem se refletir também nas condições de trabalho que, nesse caso, estão imbricadas na preservação e proteção da natureza. Devem, inclusive, formular protocolos e instrumentos como planos de contingência e planos de preparação e resposta a desastres no intuito de reduzir os danos às comunidades ou populações atingidas (FREITAS *et al*., 2018).

A ausência desses ordenamentos jurídicos ou de sua operacionalização, como ocorrido no desastre-crime do petróleo em 2019, é um reflexo da insuficiência das ações governamentais que trouxe consequências graves para a saúde e o ambiente pela exposição e contaminação por petróleo (RAMALHO; SANTOS, 2021; SOARES *et al*., 2020). Esse fato, no entanto, não deve ser analisado isoladamente, pois está sobredeterminado por processos históricos e sociais que incidem nesses territórios.

O segundo grupo de problemas – a ação antrópica sobre os ambientes de pesca – relaciona-se às modificações impostas nos territórios tradicionais causadas majoritariamente pela industrialização das atividades econômicas, pelo estabelecimento de grandes empreendimentos, tais como hidrelétricas, usinas, siderúrgicas e urbanização, por exemplo, e pelo agronegócio, neoextrativismo, desastres ou crime ambiental. Resultam em desterritorialização das comunidades pesqueiras, impedimento à continuidade da reprodução social desses grupos, poluição nos ambientes de pesca, inviabilidade da continuidade da própria atividade de pesca, procura por outras atividades produtivas, longos deslocamentos para outras áreas de pesca, entre outros prejuízos (PAULA, 2018).

Os frequentes acidentes com petróleo são um dos exemplos de como o ideário de modernidade desenfreado pode gerar danos incalculáveis às comunidades tradicionais e ao ambiente. Provoca danos no médio e longo prazo, intensificando processos de vulnerabilizações socioeconômicas, ambientais e em saúde, principalmente para essas comunidades que são socioeconomicamente dependentes do turismo e da pesca artesanal, e dos ecossistemas onde habitam, como, por exemplo, recifes de coral, estuários e manguezais, formando muitas vezes laços afetivos com esses lugares. No entanto, ainda são incipientes os estudos que analisam esses impactos de forma complexa, considerando as ressonâncias desses desastres nas condições de vida e de saúde dessa população (SILVA, 2022).

O terceiro grupo relaciona-se aos riscos à saúde atrelados à atividade da pesca. Pena e Minayo (2014) verificaram cerca de 30 diferentes tipos de doenças relacionadas ao processo de trabalho e às condições de vida em comunidades pesqueiras no estado da Bahia. Algumas das exposições e problemas identificados são semelhantes aos observados nos pescadores artesanais de Pernambuco, tais como exposição à radiação solar, hipertensão arterial sistêmica, sobrepeso ou obesidade, consumo exacerbado de tabaco e álcool, lesões por esforço repetitivo, sobrecarga de peso e problemas respiratórios causados pelo uso constante de lenha (PENA; MARTINS, 2014).

Esses problemas de saúde são decorrentes de longas e extenuantes jornadas de trabalho a que estão submetidos os trabalhadores da pesca artesanal (FALCÃO *et al*., 2019; PENA *et al*., 2014). Vale salientar que, além das enfermidades mencionadas, o derramamento de petróleo engendrou novos

processos de adoecimento nos territórios advindos da exposição ao petróleo e do sofrimento mental relacionados à perda da renda e contaminação do ambiente de trabalho (RAMALHO; SANTOS, 2021; SILVA *et al*., 2022).

Ainda que seja uma atividade autônoma, a pesca artesanal constitui-se um modo de vida e de produção que não visa unicamente ao lucro, mas que apresenta uma forte base comunitária, ou seja, existem diversas etapas do processo produtivo que envolvem e dependem de diferentes agentes no interior das comunidades – quem captura o peixe, marisco, etc., quem realiza o beneficiamento, quem vende – de forma que a cadeia seja alimentada de maneira que esses indivíduos garantam sua subsistência (NASCIMENTO, 2022; PENA *et al*., 2013; PENA; GOMES, 2014; PENA *et al*., 2014).

O derramamento de petróleo interrompeu essa organização, comprometendo a cadeia produtiva e a forma de subsistência. A ausência de ações conduzidas por instituições governamentais e o compartilhamento de notícias sem fundamento científico por veículos midiáticos fortaleceram e legitimaram o imaginário construído de que todo o pescado estaria impróprio ao consumo, reduzindo as vendas em cerca de 80% a 100% nos meses subsequentes ao início do desastre (ARAÚJO *et al*., 2020).

4 DETERMINAÇÃO SOCIAL DA SAÚDE COMO FERRAMENTA EMANCIPATÓRIA DE ANÁLISE

A partir da breve discussão das problemáticas que transpassam a existência dos povos das águas, vê-se a necessidade de compreender os impactos do derramamento de petróleo na saúde das comunidades atingidas. É necessária uma análise complexa e sistêmica que perceba como o ambiente representa uma categoria central para a manutenção de suas atividades produtivas, suas práticas culturais, seu modo de vida, e sobretudo sua reprodução social. Nesse sentido, a Determinação Social da Saúde se apresenta com o propósito de integrar a saúde aos ordenamentos sociais da vida em sentido amplo, complexo e profundo. (BREILH, 2013; PESSOA *et al*., 2018).

> Isso quer dizer que a sequência de determinações sociais, desde as características mais gerais da sociedade, dos macrodeterminantes socioeconômicos globais, até as mais particulares, dos pequenos grupos e das relações interpessoais conformam as individualidades, mas essas são ativas na escolha de si, manifestam-se ativamente em suas escolhas e atos (FLEURY-TEIXEIRA; BRONZO, 2010, p.38).

Assim, ao analisar esses impactos, deve-se observar a relação de dependência dessas populações com o ambiente onde habitam e de como a "saúde" desse ambiente determina o ritmo e a ordenação social das comunidades. Nesse sentido, podemos entender que alterações nesses ambientes ressoam nas condições de vida e na estrutura organizacional dos indivíduos. A vulnerabilização a partir do derramamento de óleo nos territórios incide em dimensões complexas e profundas que não se limitam ao subdimensionamento do pescado ou questões ambientais isoladas, mas vulnerabiliza o modo de vida, expressão maior do sujeito no território onde se reproduz socialmente (BRANDÃO, 2010; BREILH, 2013).

A compreensão de território é considerada com base em Santos (1999), que o define como sendo a expressão de coragem, autenticidade e força para promover ferramentas de proteção contra processos destrutivos:

> O território tem que ser entendido como o território usado, não o território em si. O território usado é o chão mais a identidade. A identidade é o sentimento de pertencer àquilo que nos pertence. O território é o fundamento do trabalho, o lugar da residência, das trocas materiais e espirituais e do exercício da vida (SANTOS, 1999, p. 08).

É a partir dessa correlação que as comunidades tradicionais da pesca alcançam a autonomia em relação aos seus processos sociais e de trabalho, mas, por diversas vezes, pode ser atravessada por conflitos socioambientais, como os promovidos pela carcinicultura, por exemplo; pelo avanço do neoextrativismo, modelo central na economia do Brasil; por desastres e injustiças ambientais, tornando sua autonomia relativa (BRANDÃO, 2010; RIGOTTO *et al*., 2018). Tais processos subsomem-se a outros fenômenos que se sobredeterminam e que devem ser considerados na observação dos processos instaurados nos territórios, pois influenciam as condições de saúde e de recuperação de desastres, tais como o derramamento de petróleo.

Os desastres intensificam os processos de vulnerabilização socioambientais das populações que vivem, historicamente, em situações de vulnerabilidade e evidenciam as limitações na capacidade de compreender a saúde segundo as particularidades dos indivíduos e seus grupos sociais, como é o caso das comunidades tradicionais que vivem sob circunstâncias particulares. Pois, sendo o indivíduo formado por singularidades biológicas, perenes à própria condição e fatores políticos, socioeconômicos, culturais e espirituais, a construção do que é saúde dá-se a partir de uma ordem de intersubjetividades criadas num primeiro momento, numa construção comunal e depois societal (SAMAJA, 2000).

Portanto, saúde é um fenômeno multifacetado, influenciado e determinado por diversos marcadores e processos sociais, que interpelam os sujeitos e coletivos. A implicação da abordagem sistêmica, por meio da análise da determinação social da saúde em grupos culturais distintos, torna-se cada vez mais necessária para compreender o universo social e cultural dos indivíduos ao confrontar diversos contextos, experiências e valores (CONCONE, 2003).

A Política Nacional de Saúde Integral dos Povos do Campo, das Florestas e das Águas (PNSIPCFA) mostra o quanto ainda é preciso caminhar no atendimento às necessidades desses povos. A política compreende e alerta para a existência de uma diversidade de comunidades que coexistem no ambiente rural, assim como dá luz à variedade de necessidades que emergem desse tipo de relação próxima à terra, às florestas, aos campos e, nesse caso, às águas (BRASIL, 2014).

Levando isso em conta, vê-se que tais necessidades emergem tanto das relações de trabalho, construídas e perpetuadas nesse tipo de ambiente, como das transformações ambientais impostas pelo modelo produtivo – este impacta na saúde das comunidades, assim como compromete uma gama de saberes e práticas que conformam sua identidade e soberania (BRASIL, 2014). Tais injustiças têm como consequência diversos processos de vulnerabilização da vida em seus aspectos sociais, econômicos, culturais e espirituais, provocando adoecimento e, muitas vezes, a morte (PORTO, 2014).

5 CONSIDERAÇÕES FINAIS

A compreensão da saúde, seja para a manutenção do estado saudável, seja no manejo dos processos de adoecimento, deve ser pensada em uma perspectiva multidimensional, sistêmica e convergente, sem sobrepujar a realidade particular de cada comunidade ou povo, pela intransponível e complexa barreira da totalidade, que abriga em seu status quo multifaces da vida, inerentes à história social desses indivíduos.

Pressupõe-se, assim, que os impactos do derramamento de petróleo sejam pensados a partir da complexidade da reprodução dos processos de vida e da saúde, os quais são intrínsecos à construção dos sentidos e dos sentimentos que nessas comunidades acontecem de forma subjetiva e divergente das ideias desenvolvimentistas e globalizadoras. Ademais, a utilização de métodos estritamente tecnicistas, a partir de um olhar centralizado na intervenção sobre o corpo, numa lógica de causa-efeito é insuficiente. E constitui uma ação fragmentada de saúde que pode causar o acirramento das vulnerabilidades já existentes.

Desconsiderar o indivíduo como um ser "plurisistêmico" é furtar a dinâmica existencial da vida, isolando-o dos processos socioambientais, tratando a saúde como um elemento estático e não como um processo de compensações e vivências. O processo histórico dos indivíduos, a sua relação com a natureza, sua espiritualidade e cosmovisão mostram como experimentam o mundo e concebem a sua compreensão de saúde.

Por fim, devem ser consideradas neste artigo as limitações para esse gênero textual. Reiteramos que o texto considera e prioriza os postulados teóricos defendidos pelos autores e representa, em certa medida, a defesa de uma tese baseada em expertises do campo da Saúde, Ambiente e Trabalho

REFERÊNCIAS

ACSELRAD, H. Ambientalização das lutas sociais: o caso do movimento por justiça ambiental. **Estudos Avançados**, São Paulo, v. 24, n. 68, p. 103-119, 2010. Available at: http://www.scielo.br/scielo.php?script= sci_arttext & pid=S0103-40142010000100010 & lng= en\ nrm=iso.

ACSELRAD, H. O conhecimento do ambiente e o ambiente do conhecimento: anotações sobre a conjuntura do debate sobre vulnerabilidade. **Em Pauta**, v. 11, n. 32, p. 115-129, 2017.

ALMEIDA FILHO, N. Modelagem da pandemia da Covid-19 como objeto complexo (notas samajianas). **Estudos Avançados**, v. 34, n. 99, p. 97-118, 2020. Available at: http://dx.doi.org/10.1590/s0103-4014.2020.3499.007

ARAÚJO, I. M. M.; OLIVEIRA, Â. G. R. C. Interfaces entre a saúde coletiva e a ecologia política: vulnerabilização, território e metabolismo social. **Saúde em Debate**, v. 41, n. 2, p. 276-286, 2017. Available at: https://dx.doi.org/10.1590/0103-11042017s223

ARAÚJO, M. E.; RAMALHO, C. W. N.; MELO, P. W. Pescadores artesanais, consumidores e meio ambiente: consequências imediatas do vazamento de petróleo no Estado de Pernambuco, Nordeste do Brasil. **Cad. Saúde Pública**, Rio de Janeiro, v. 36, n. 1. 2020. Available at: https://doi.org/10.1590/0102-311X00230319

BRANDÃO, C. R. A comunidade tradicional. In: COSTA, J. B. A.; LUZ, C. (Org.). **Cerrados, Gerais, Sertão**: comunidades tradicionais dos sertões Roseanos. Montes Claros: Intermeios, p. 347-361, 2010. Available at: http://nupaub.fflch.usp.br/sites/nupaub.fflch.usp.br/files/a%20comunidade%20trad160.pdf

BRASIL. **Lei n. 10.779, de 25 de novembro de 2003**. Dispõe sobre a concessão do benefício de seguro-desemprego, durante o período de defeso, ao pescador profissional que exerce a atividade pesqueira de forma artesanal. Available at: http://www.planalto.gov.br/ccivil_03/leis/2003/l10.779.htm. Accessed on: 12 ago. 2022.

BRASIL. Lei n. 11.959, de 29 de junho de 2009. Dispõe sobre a política nacional de desenvolvimento sustentável da aquicultura e da pesca e dá outras providências. **Diário Oficial da República Federativa do Brasil**, Brasília, DF, n. 122, p.1-3, 30/06/2009. Seção 1.

BRASIL. **Portaria nº 2.311, de 23 de outubro de 2014**. Altera a Portaria nº 2.866/GM/MS, de 2 de dezembro de 2011, que institui, no âmbito do Sistema Único de Saúde (SUS), a Política Nacional de Saúde Integral das Populações do Campo e da Floresta (PNSIPCF). 2014.

BREILH, J. La determinación social de la salud como herramienta de transformación hacia una nueva salud pública (salud colectiva). **Revista Faculdad Nacional de Salud Pública**, v. 31, n. supl 1, p. 13–27, 2013. Available at: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-386X2013000400002

CARMO, E. H.; TEIXEIRA, M. G. Desastres tecnológicos e emergências de saúde pública: o caso do derramamento de óleo no litoral do Brasil. **Cadernos de Saúde Pública** [online]. 2020, v. 36, n. 2 [Acessado em 12 ago. 2022], e00234419. Available at: https://doi.org/10.1590/0102-311X00234419 Epub 31 Jan 2020. ISSN 1678-4464.

CONCONE, M. H. V. B. Os Sentidos da Saúde: uma abordagem despretensiosa. In: GOLDENBERG, P. (Org.) **O Clássico e o Novo**: tendências, objetos e abordagens em ciências sociais e saúde. Rio de Janeiro: Editora Fiocruz, 2003.

CONSELHO PASTORAL DA PESCA. **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil**: relatório 2021. BARROS, S.; MEDEIROS, A.; GOMES, E. B. (Org.) 2nd ed. Olinda, 2021. ISBN 978-65-992464-5-6.

CROISANT, S.; SULLIVAN, J. Studying the Human Health and Ecological Impacts of the Deep Water Horizon Oil Spill Disaster: introduction to this special issue of New Solutions. **New Solutions: A Journal of Environmental and Occupational Health Policy**, v. 28, n. 3, p. 410–415, 2018. Available at: http://journals.sagepub.com/doi/10.1177/1048291118795691.

CUNHA, A. M. **A colonização e o desenvolvimento capitalista do Brasil**. 2012. Available at: http://www.ufrgs.br/decon/publionline/textosdidaticos/textodid14.pdf.

D'ALMEIDA, A. L. **Indústria do petróleo no Brasil e no mundo**: formação, desenvolvimento e ambiência atual. Editora Blucher, 2015.

D'ALMEIDA, A. L. **O fim da era do petróleo está próximo?** Fundação Getúlio Vargas. Energia. 2019.

DIEGUES, A. C. S. **Pescadores, camponeses e trabalhadores do mar**. São Paulo: Ática, 1983.

DOMINGUES, R. C. C.; SANTOS, M. O. S.; GURGEL, I. G. D. A vulneração socioambiental advinda do complexo industrial portuário de Suape: a perspectiva dos moradores da Ilha de Tatuoca–Ipojuca/PE. **Tempus Actas de Saúde Coletiva**, v. 8, n. 2, p. 69-91, 2014. Available at: https://doi.org/10.18569/tempus.v8i2.1513

EL-SAYED, A.; KAMEL, M. Climatic changes and their role in emergence and re-emergence of diseases. **Environ Sci Pollut Res Int**, v. 27, n. 18, p. 22336-22352, 2020. DOI 10.1007/s11356-020-08896-w

EPE. Empresa de Pesquisa Energética. **Balanço Energético Nacional 2022**. Available at: https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-675/topico-631/BEN_S%C3%ADntese_2022_PT.pdf

FALCÃO, I. R. *et al*. Fatores associados com os distúrbios musculoesqueléticos em pescadoras artesanais/marisqueiras em Saubara, Bahia, Brasil. **Ciência & Saúde Coletiva** [online]. 2019, v. 24, n. 7 [Acessado em 12 ago. 2022], p. 2557-2568. Epub 22 Jul 2019. ISSN 1678-4561. Available at: https://doi.org/10.1590/1413-81232018247.19712017.

FAO. 2020. **The State of World Fisheries and Aquaculture 2020**. Sustainability in action. Rome. Available at: https://doi.org/10.4060/ca9229en.

FLEURY-TEIXEIRA, P.; BRONZO, C. **Determinação social da saúde e reforma sanitária**. In: NOGUEIRA, R. P. (org.). Determinação social da saúde e política. Rio de Janeiro: Cebes, 2010.

FREITAS, M. I. C.; CUNHA, L. Cartografia da vulnerabilidade socioambiental: convergências e divergências a partir de algumas experiências em Portugal e no Brasil. **Urbe. Revista Brasileira de Gestão Urbana**, v. 5, n. 1, p. 15-31, 2013. Available at: https://dx.doi.org/10.7213/urbe.7783.

GASPAR, R. C. A trajetória da economia mundial: da recuperação do pós-guerra aos desafios contemporâneos. **Cadernos Metrópole** [online]. 2015, v. 17, n. 33 [Acessado em 25 jul. 2022] p. 265-296. Available at: https://doi.org/10.1590/2236-9996.2015-3312

GOLDSTEIN, B. D.; OSOFSKY, H. J.; LICHTVELD, M. Y. The Gulf Oil Spill. **New England Journal of Medicine**, v. 364, n. 14, p. 1334–1348, 2011. Available at: http://www.nejm.org/doi/abs/10.1056/NEJMra1007197

GUIMARÃES, S. R.; ANDRADE, M. R. F. L. Pesca artesanal: reflexões sobre políticas públicas na Colônia de Pescadores Z-33 em Porto Jatobá, Pernambuco. **Interações** (Campo Grande), v. 21, p. 347-361, 2020. Available at: https://doi.org/10.20435/inter.v21i2.2167

GURGEL, A. M. *et al*. Framework dos cenários de risco no contexto da implantação de uma refinaria de petróleo em Pernambuco. **Ciência & Saúde Coletiva**, v. 14, n. 6, p. 2027–2038, 2009. Available at: https://doi.org/10.1590/S1413-81232009000600010

GURGEL, A. M. *et al*. Uso do coque verde de petróleo como matriz energética e potenciais danos à saúde e ao ambiente. In: SANTOS, M. O. S.; GURGEL, A. M.; GURGEL, I. G. D. **Conflitos e injustiças na instalação de refinarias**: os caminhos sinuosos de Suape, Pernambuco. Recife: Ed. UFPE, p. 119-146, 2019.

GURGEL, A. M. **Uso do coque verde de petróleo como matriz energética em Pernambuco e a perspectiva da vigilância em saúde**: estudo de caso no Complexo Industrial Portuário de Suape. Dissertação (Mestrado Acadêmico em Saúde Pública) – Centro de Pesquisas Aggeu Magalhães, Fundação Oswaldo Cruz. Recife, p. 159. 2011.

LAFFON, B.; VALDIGLESIAS, V.; PASÁRO, E. Effects of Exposure to Oil Spills on Human Health: updated review article. **Journal of Toxicology and Environmental Health Part B**: critical reviews, v. 19, n. 03, p. 1-24, 2016. Available at: https://www.researchgate.net/publication/303511825_Effects_of_Exposure_to_Oil_Spills_on_Human_Health_Updated_Review.

MARTINEZ-ALIER, J. *et al*. (Forthcoming) Is there a global environmental justice movement? **Journal of Peasant Studies**, v. 43, n. 3, p. 731-755, 2016. Available at: https://doi.org/10.1080/03066150.2016.1141198

MATTOS, S. M. G.; WOJCIECHOWSKI, M. J.; GANDINI, F. C. **Iluminando as Capturas Ocultas da Pesca Artesanal Costeira no Brasil**: um estudo de caso. Relatório Executivo. Food and Agriculture Organization of the United Nations (FAO), the WorldFish, and the University of Duke (Orgs.).

MENDONÇA, J. T.; MATTOS, S. M. G. Panorama da política pesqueira no Brasil em 2020. In: **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil**: relatório. Conselho Pastoral dos Pescadores. Available at: http://www.cppnacional.org.br/publicacao/relat%C3%B3rio-dos- conflitos-socioambientais-e-viola%C3%A7%C3%B5es-de-direitos-humanos%C2%A0em%C2%A0comunidades. 2021.

MESQUITA, B.; QUINAMO, T. **Impactos socioeconômicos e ambientais da contaminação por petróleo nas praias do litoral da Região Nordeste do Brasil**. Recife. p. 41. 2020.

MOREIRA, J. F. M. **Acidentes na indústria de petróleo e seus impactos na segurança operacional e preservação ambiental**. Trabalho de conclusão (Bacharelado em Engenharia do Petróleo) – Universidade Federal Fluminense. Niterói, p.100. 2017.

NASCIMENTO, A. M. S. **A relação trabalho-saúde das marisqueiras na atividade da pesca artesanal**: revisão integrativa da literatura. 2022. 70 folhas. Trabalho de Conclusão de Curso (Graduação em Biomedicina) – Universidade Federal de Pernambuco, Recife, 2022.

OLIVEIRA, O. M. B. A.; SILVA, V. L. O Processo de Industrialização do Setor Pesqueiro e a Desestruturação da Pesca Artesanal no Brasil a partir do Código de Pesca de 1967. **Sequência**, p. 329-357, 2012. Available at: http://dx.doi.org/10.5007/2177-7055.2012v33n65p329

PATZ, J. A. *et al*. Climate change: challenges and opportunities for global health. **JAMA**, v. 312, n. 15, p. 1565-1580. 2014. DOI 10.1001/jama.2014.13186

PAULA, C. Q. Impactos ambientais na pesca artesanal brasileira: uma interpretação geográfica. **PerCursos**, v. 19, n. 41, p. 79-106, 2018. Available at: https://doi.org/10.5965/1984724619412018079

PENA, P. G. L.; GOMEZ, C. M. Saúde dos pescadores artesanais e desafios para a Vigilância em Saúde do Trabalhador. **Ciência & Saúde Coletiva**, v. 19, p. 4689-4698, 2014. Available at: https://doi.org/10.1590/1413-812320141912.13162014

PENA, P. G. L. *et al*. Derramamento de óleo bruto na costa brasileira em 2019: emergência em saúde pública em questão. **Cadernos de Saúde Pública** [online]. v. 36, n. 3. Available at: https://doi.org/10.1590/0102-311XER231019. ISSN 1678-4464. Accessed on: 12 ago. 2022.

PENA, P. G. L.; GOMEZ, C. M. Health of subsistence fishermen and challenges for Occupational Health Surveillance. **Ciência & Saúde Coletiva** [online]. 2014, v. 19, n. 12, p. 4689-4698. ISSN 1678-4561. Available at: https://doi.org/10.1590/1413-812320141912.13162014

PENA, P. G. L.; MARTINS, V.; RÊGO, R. F. Por uma política para a saúde do trabalhador não assalariado: o caso dos pescadores artesanais e das marisqueiras. **Rev. Bras. Saúde Ocup**, v. 38, n. 127, p. 57-68. 2013. Available at: https://doi.org/10.1590/S0303-76572013000100009

PÉREZ, M. S. **Re-existências dos camponeses/as do que hoje é Suape**: justiça territorial, pós-desenvolvimento e descolonialidade pela vida. 2016. Tese (Doutorado Acadêmico em Geografia) – Universidade Federal de Pernambuco, Recife, 2016.

PESSOA, V. M.; ALMEIDA, M. M.; CARNEIRO, F. F. Como garantir o direito à saúde para as populações do campo, da floresta e das águas no Brasil? **Saúde em Debate**, v. 42, p. 302-314, 2018. Available at: https://doi.org/10.1590/0103-11042018S120

PORTO, M. F. S.; ROCHA, D. F.; FINAMORE, R. Saúde coletiva, território e conflitos ambientais: bases para um enfoque socioambiental crítico. **Ciência & Saúde Coletiva**, v. 19, n.10, p. 4071-4080, 2014. Available at: https://doi.org/10.1590/1413-812320141910.09062014

PORTO, M. F. S. Complexidade, processos de vulnerabilização e justiça ambiental: um ensaio de epistemologia política. **Revista Crítica de Ciências Sociais**, v. 93, p. 31-58, jun 2011. Available at: https://doi.org/10.4000/rccs.133

RAMALHO, C. W. N.; SANTOS, S. A. O cotidiano das comunidades pesqueiras: entre o petróleo e o novo coronavírus. *In:* **Conflitos socioambientais e violações de direitos humanos em comunidades tradicionais pesqueiras no Brasil. 2021**. BARROS, S.; MEDEIROS, A.; GOMES, E. B. (Orgs). 2nd ed. Olinda. Conselho Pastoral dos Pescadores. ISBN 978-65-992464-5-6.

REDDY, C. M. *et al*. **Synergy of Analytical Approaches Enables a Robust Assessment of the Brazil Mystery Oil Spill**. 2022. Energy & Fuels Article ASAP. DOI 10.1021/acs.energyfuels.2c00656

RÊGO, R. F. R. *et al*. Vigilância em saúde do trabalhador da pesca artesanal na Baía de Todos os Santos: da invisibilidade à proposição de políticas públicas para o Sistema Único de Saúde (SUS). **Revista Brasileira de Saúde Ocupacional**, v. 43, p. 1-9, 2018. Available at: https://doi.org/10.1590/2317-6369000003618

RIBEIRO, H. Impactos da Exploração do Petróleo na Saúde Humana. **Revista USP**, v. 1, n. 95, p. 61-71, 2012. Available at: http://www.revistas.usp.br/revusp/article/view/52239

RIGOTTO, R. M.; AGUIAR, A. C. P.; RIBEIRO, L. A. D. **Tramas para a Justiça Ambiental**: diálogo de saberes e práxis emancipatórias. Fortaleza: Edições UFC, 2018.

SAMAJA, J. **Reprodução Social e a Saúde**. Salvador: Casa da Qualidade Editora, 2000.

SANTOS, M. O. S. *et al*. **Oil in Northeast Brazil**: mapping conflicts and impacts of the biggest disaster on the country's coast. 2022. Anais da Academia Brasileira de Ciências [online]. 2022. Available at: https://doi.org/10.1590/0001-3765202220220014

SANTOS, M. O. S.; GURGEL, A. M.; GURGEL, I. G. D. **Conflitos e injustiças na instalação de refinarias**: os caminhos sinuosos de Suape, Pernambuco. Ed. Universitária da UFPE. Recife, 2019.

SANTOS, M. O. S. **Vulneração e injustiças ambientais na determinação social da saúde no território de Suape, Pernambuco/Brasil**. 2017. Tese (Doutorado Acadêmico em Saúde Pública) – Instituto Aggeu Magalhães, Fundação Oswaldo Cruz. Available at: https://www.arca.fiocruz.br/handle/icict/28046.

SANTOS, M. **O dinheiro e o território**. 1st ed. Rio de Janeiro: GEOgraphia,1999. 7-13 p.

SILVA, A. P. Pesca artesanal brasileira: aspectos conceituais, históricos, institucionais e prospectivos. **Embrapa Pesca e Aquicultura**. Boletim de Pesquisa e Desenvolvimento, 2014.

SILVA, J. M. da. **A perspectiva da saúde nos Estudos de Impacto Ambiental de megaprojetos de infraestrutura no Brasil**: uma análise bioética e epistemológica. 2017. Tese (Doutorado em Saúde Pública) – Instituto Aggeu Magalhães, Fundação Oswaldo Cruz. Recife, 2017.

SILVA, F. R. da *et al*. Oil Spill and Socioeconomic Vulnerability in Marine Protected Areas. **Frontiers in Marine Science**, p. 718, 2022. Available at: https://doi.org/10.1590/0102-311X00234419.

SOARES, E. C. *et al*. Impacto do petróleo no meio ambiente e nos organismos aquáticos nas costas dos estados de Alagoas e Sergipe, Brasil: uma avaliação preliminar. **Touro Poluente Mar**, 2021. Available at: 10.1016/j.marpolbul.2021.112723.

SOARES, M. O. *et al*. Oil spill in South Atlantic (Brazil): environmental and governmental disaster. **Marine Policy**, v. 115, 103879. 2020. Available at: https://doi.org/10.1016/j.marpol.2020.103879

SOARES, M. O.; TEIXEIRA, C. E. P.; BEZERRA, L. E. A. O derramamento de óleo mais extenso registrado nos oceanos tropicais (Brasil): o balanço de um desastre. **Environmental Science and Pollution Research**, v. 29, n. 13, p. 19869-19877. 2022. Available at: https://doi.org/10.1007/s11356-022-18710-4.

TAKESHITA, R.; BURSIAN, S. J.; COLEGROVE, K. M. A review of the toxicology of oil in vertebrates: what we have learned following the Deepwater Horizon oil spill. **Journal of Toxicology and Environmental Health, Part B**, v. 24, n. 8, p. 355-394, 2021. Available at: https://doi.org/10.1080/10937404.2021.1975182

VIGLIO, J. E. *et al*. Narrativas científicas sobre petróleo e mudanças do clima e suas reverberações na política climática brasileira. **Sociologias** [online], v. 21, n. 51, p. 124-158. Available at: https://doi.org/10.1590/15174522-0215105. 2019.

Cultural aspects for adaptation to the climate change impacts on the Ecosystem Services in a case study of Central Amazon

Aspectos culturais para adaptação aos impactos das mudanças climáticas nos Serviços Ecossistêmicos em um estudo de caso da Amazônia Central

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ABSTRACT

Climate adaptation tends to face resistance or produce adverse effects, if it is tested only on the generalist scientific models, ignoring its effects on the culture, values, and worldviews of local communities. This article investigates how climate change has threatened the livelihood and cultural dimensions of peri-urban communities in the Central Amazon. The analysis is based on the cultural theory of risk in climate adaptation and its relationships to local Ecosystem Services (ES). In this case study, semi-structured interviews were conducted with residents of three municipalities in the Metropolitan Area of Manaus – Brazil. Given that their diet used to be heavily based on native food, the results show how Amazonian communities are adapting their eating habits in response to climate and environmental changes to the ES decline in the category of food security (i.e., in the class of provisioning ES). In addition, these services have relevant cultural value (i.e., cultural services). The ES reduction influences adaptation strategies amid the dismantling of current environmental policies. As a result, these communities began to adopt industrialized means of production and consumption, such as adopting products derived from cattle, whose production is the main cause of greenhouse gas emissions in Brazil. Therefore, the studied case demonstrates how climate adaptation may pressure and erode local cultures, when these following the logic of globalized urbanization.

Keywords: Climate change. Ecosystem services. Cultural identities. Amazon communities. Adaptation strategies.

RESUMO

A adaptação climática tende a enfrentar resistências ou produzir efeitos adversos, se for testada apenas nos modelos científicos generalistas, ignorando seus efeitos na cultura, valores e visões de mundo das comunidades locais. Este artigo investiga como a mudança climática tem ameaçado a subsistência e as dimensões culturais das comunidades periurbanas na Amazônia Central. A análise é baseada na teoria cultural do risco na adaptação climática e suas relações com os serviços ecossistêmicos (SE) locais. Neste estudo de caso, foram realizadas entrevistas semiestruturadas com moradores de três cidades da Área Metropolitana de Manaus – Brasil. Devido à sua dieta ser fortemente baseada em alimentos nativos, os resultados mostram como as comunidades amazônicas estão adaptando seus hábitos alimentares em resposta às mudanças climáticas e ambientais ao declínio no SE na categoria de segurança alimentar (ou seja, na classe de abastecimento SE). Além disso, esses serviços têm valor cultural relevante (ou seja, serviços culturais). A redução do SE influencia as estratégias de adaptação em meio ao desmonte das atuais políticas ambientais. Com isso, essas comunidades passaram a adotar modos de produção e consumo industrializados, como a adoção de produtos derivados da pecuária, cuja produção é a principal causadora das emissões de gases de efeito estufa no Brasil. Portanto, o caso estudado demonstra como a adaptação climática pode pressionar e corroer as culturas locais, quando estas seguem a lógica da urbanização globalizada.

Palavras-chave: Mudanças climáticas. Serviços ecossistêmicos. Identidade cultural. Comunidades amazônicas. Estratégias adaptativas.

1 INTRODUCTION

Climate change models run to South America demonstrate that risk of heat stress exposure in the future scenarios was highest in Northern Brazil, where one of the most vulnerable populations is located on the continent. In a climate change perspective, the Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as “the propensity or predisposition to be adversely affected.” Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and to adapt (IPCC, 2014). Therefore, adaptation represents the process of adjustment to current or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate changes and its effects

(IPCC, 2014). However, the social dimensions of climate change go beyond biophysical impacts and concern the social and structural factors fundamental to vulnerability (OTTO *et al*., 2017), especially regarding populations with economic and cultural activities that are well tied to the ecosystem, as is the case of the Amazonian peoples.

Regarding these concepts, the increase in research on cultural dimensions of climate change reflects the understanding that the success of adaptation initiatives depends as much on social, political, demographic, and cultural factors (NOLL *et al*., 2020) as it does on applying technologies based on biophysical solutions, such as renewable energy (OTTO *et al*., 2020). However, scientific data have neglected local cultural aspects by standardizing the perception and the socio-environmental impacts related to climate change in a Universalist approach (ADGER *et al*., 2013).

Thus, it tends to replay the current hegemonic model of production and consumption, where humans and nature are dualistic elements of a market, which ignores cultural identities and local and traditional knowledge. In the context of climate crisis, these manifests as a preference for scientific praxis focused on quantitative data and on provision and regulation Ecosystem Services (ES), harming Cultural Ecosystem Services (CES), which encompass the multiple dimensions of how people identify, signify and value the environment (DOUGLAS; WILDAVSKY, 1982).

Extreme weather events are examples of the connection between climate and culture since those events affect spaces that shelter cultural identities, histories, and traditions. The damage to cultural and natural heritage is sometimes irrecoverable, and the cost to human lives and to the physical and mental health of the populations affected is immeasurable (SEIXAS; NUNES, 2017). The cumulative effects include problems in water supply, outbreaks of diseases, changes in cropping systems and consequent changes in eating habits, besides population migration (BRONDÍZIO *et al*., 2016).

Another relevant aspect is the pressure on dietary patterns caused by climate change, especially in isolated populations, who are the most affected by food insecurity and water scarcity and take refuge in urban areas (ADGER, 2013). This tendency erodes the transmission of local cultural expressions (stories, myths, songs, language, and images) due to the interruption of the process of socialization for young people who leave the countryside searching for work in urban areas. The depletion of natural products reflects on social, economic, and cultural interactions, as human well-being relies on the benefits from the natural environment, such as the provision of wild food, water, and air (KADYKALO *et al*., 2019). Thus, generally, all these aspects represent serious risks to the socio-ecological and biocultural system.

Therefore, the general objective of this study is to understand the relationship between impacts of climate change on Ecosystem Services (ES) and their effects on the cultural aspects of the way of life of local populations. From that understanding, the specific objective was to analyse what are the adaptation strategies employed by communities due to these impacts in a case study of a peri-urban region from Brazil. The results should contribute to the resumption of sociocultural aspects in the ES management.

2 ENVIRONMENTAL RISKS, CULTURE, AND CAPACITY BUILDING

LIn a more technical conceptual view, risks refer to the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems, and species (IPCC, 2021).

Therefore, considering one of the fundamental elements for well-being – food security –, climate change can affect the provisioning of ecosystem services, for example, directly, with food supply losses from varied systems and crop failures, or indirectly, with increased food prices caused by decreased supply (OTTO *et al*., 2017). Furthermore, the logical expansion of land use on a large scale causes environmental degradation due to the expansion of means of production displacing or compromising the livelihoods of local communities and traditional peoples based on ecosystems, who are pushed to join the global community or perish (SEIXAS *et al*., 2014). About 30 years ago, Giddens (1991) dealt with the fact that globalization distances society as a system and focuses on ordering social life in time and space. As a result, three consequences can be observed: the disintegration of national identities with cultural homogenization; the reinforcement of nationalism as resistance to globalization; and the emergence of new identity configurations.

According to Douglas (1992), the ways in which environmental risks are perceived correspond to different types of worldviews that order values, beliefs, impressions, feelings, and conceptions of a group in two dimensions: affiliation (collective) or grid (social rules). Thus, the Cultural Theory of Risk allows us to understand how different adaptive strategies guided by the cultural context in which the agents are inserted and established (DOUGLAS, 1992). Therefore, the Cultural Ecosystem Services (CES) is an abstraction and can be symbolized by people's wishes and desires, by which culture uses elements of nature to provide vital needs such as food and to support particular lifestyles, even though the activities could degrade the very products on which people depend to live (DAILY, 2013).

The concept of CES derives from the ES, which emerged in the 1970s to fill the gaps in valuing the natural system on the political agenda (DAILY, 2013). The ES are categorized as provisioning (food, freshwater, and wood) and regulating (climate, disease control, and air quality; productive soils and nutrient cycling) (BURKHARD *et al*., 2014; MEA, 2005). The CES also describes non-material, non-monetary, and non-tangible benefits, obtained via spirituality, reflection, knowledge, recreation, and aesthetic experiences that influence human well-being (CICES, 2018; REID *et al*., 2005) and is classified into two categories: those related to physical and intellectual interactions with ecosystems and those related to spiritual or symbolic interactions (Table 1).

Moreover, analysing CES is a complex task since different people construct culture in different ways, depending on their ancestries, experiences, cultural heritage, age, and gender, as well as their local environment (PLIENINGER *et al*., 2013). However, such services are fundamental to well-being in tangible and intangible way as described by Russell *et al*. (2013) in ten typologies: i) physical health; ii) mental health; iii) spirituality; iv) sense of control and security; v) learning and capacity building; vi) inspiration/accomplishment; vii) sense of place; viii) identity and autonomy; ix) sense of connection and belonging; and x) subjective sense of general well-being.

Table 1 | International Classification of Ecosystem Services

Category	*Division*	*Group*
Provisioning	Nutrition	- Crops, fish, livestock, wild food - Freshwater
	Biomass and water	- Fibres, Timber - Water (ex. domestic and industrial use)
	Energy	- Energy source based on biomass (ex. wood fuel) - Energy source based on ecosystem properties (ex. wind and geothermal energy)

Category	Division	Group
Regulating & Maintenance	Regulation of waste, toxics and nuisances	- Mediation by biota - Mediationnby ecosystem
	Regulation of flows	- Mass flows (ex. erosion control) - Liquid flows (ex. surface runoff control) - Gaseous flows (ex. regulation of pollution)
	Regulation of physical, chemical, biological conditions	- Lifecycle maintenance, habitat and gene pool protection - Pest and disease control - Nutrient regulation - Ait quality and climate regulation
Cultural	Intellectual and representative interactions with abiotic components of tha nautural environment	- Recreation and Tourism - Aesthetic and inspiration experiences
	Spititual, symbolic and other interactions with the abiotic components of the natural environment	- Spiritual and religious values - Cultural and natural heritage

Source: Elaborated by the authors based on Burkhard et al. (2014) and Cices (2013).

A case of the relationship between nature-culture in the Amazon Forest is about how cultural beliefs and folkloric symbology drive interactions with the ecosystem. For example, myths and legends of the indigenous peoples of the Amazon that present forest guardians such as the Curupira . In addition, the Mother Nature concept, which is a Sumaúma tree, "who" is able to protect the animals, the soil, and the watershed that, together with the other trees in the forest, reduces air pollution, regulates the climate, and maintains biodiversity. "Many values emerge from cultural processes and influence assessments that support environmental behaviours and policies, which in turn influence cultural processes" (COMBERTI *et al.*, 2015).

In this sense, the capacity building is also flourishing, from the cultural organisation of adaptation strategies to climate change. Among the adaptation types, autonomous adaptation entails the spontaneous or ongoing implementation of existing knowledge and techniques, whereas planned adaptation involves intentional efforts to engage information about present and future change considering the suitability of current and planned practices and policies often with direct government assistance (FISCHER, 2019; FÜSSEL, 2007; SZLAFSZTEIN; ARAÚJO, 2021).

3 METHODOLOGICAL PROCEDURES

The descriptive method of this study is based on precepts of the Cultural Theory of Risk model (DOUGLAS, 1992) and applied in a case study in a peri-urban region of Brazil in the cities of Itacoatiara and Silves, in the Metropolitan Area of Manaus (MAM), state of Amazonas. These cities were chosen due to their peripheral location on the urban-rural border of the Global South. The MAM underwent rapid development since the second half of the 20th century and is intensely influenced by globalization, until today. From those particular regional characteristics, we sought to highlight the mediating effect of local culture in perceiving and reacting to the impacts of global climate change that are a tendency in developing countries. Thus, the investigation was guided by three questions:

I. How do the effects of climate change pressure ES related to the local way of life and culture?

II. How ways of life and culture are determinant for adaptation strategies to climatic events at the local level?

III. Which adaptive strategies were developed by these populations to maintain the food supply?

3.1 CHARACTERIZATION OF STUDY AREA

3.1.1 METROPOLITAN AREA OF MANAUS, AMAZON, BRAZIL

The Amazon is one of the few broad areas of tropical rainforest on the planet contemplating the ES supply on a local, regional, and global scale (DAVIDSON *et al*., 2012). The case study was carried out in the MAM in the Central Brazilian Amazonia, which is representative of the study, since it still preserves traditional communities and economic and cultural identity based on the ecosystem.

The region has peri-urban characteristics resulting from the accelerated economic growth and globalization process, which began in the rubber period at the end of the 19th century (BARHAM; COOMES, 1994). This process also intensified in the 20th century, when the federal government approved the establishment of a Free Trade Zone (Zona Franca de Manaus) facilitating investments and industrialization but generating disorderly urban occupation and predatory exploitation of nature (KANAI, 2014).

Manaus is the most populous city in the North of Brazil, with an estimated 2,255,903 inhabitants and a Human Development Index (MHDI) of 0.737 (IBGE, 2021; UNDP, 2010). The city occupies an area of 11,400 km², at the confluence of Negro and Solimões Rivers, forming the Amazon River (IBGE, 2022). Located in the "heart" of the Amazon Forest, it is considered an important centre for regional development and ecological tourism. The municipality has the most thriving economy in the region, given the Industrial Pole of Manaus (Free Trade Zone), one of the largest industrial parks in Latin America, concentrating 80% of the Amazonas's Gross Domestic Product (RIBEIRO, 2012). Currently, Manaus is the seventh-largest Brazilian city (IBGE, 2019). However, despite its position, half of the population lives in poverty (KANAI, 2014).

Cities such as Itacoatiara and Silves were selected in the sample due to exerting great economic influence within the metropolitan area. Itacoatiara is the third-largest city in Amazonas State with an estimated 104,046 inhabitants, considered medium-size, intermediate to Manaus, and has easy access to large international vessels through the Amazon River (SCHOR; MARINHO, 2013).

On the other hand, the municipality of Silves has around 9,000 inhabitants, an island city with rich aquatic diversity; thereby the local communities have fishing as their main source of subsistence. Concerning the local economy, small-scaled livestock, agriculture, extractive fishing, poultry, and plant extractives are the main activities (IBGE, 2010; UNDP, 2010), which make it an important supplier to neighbouring urban areas.

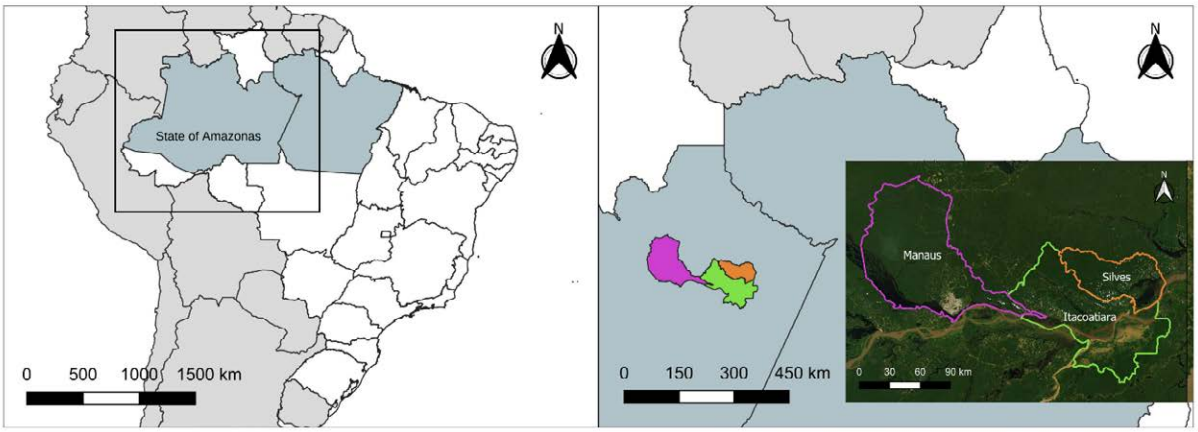

Figure 1 | Study area. Municipalities of Manaus, Silves, and Itacoatiara in the southeast of the state of Amazonas, representing the Metropolitan Area of Manaus

Source: Elaborated by the authors.

3.1.2 COLLECTION AND ANALYSIS OF DATA OF THE METROPOLITAN AREA OF MANAUS

The data was analysed with an approach of perception. Research based on perception has been employed in diverse knowledge fields (RODRIGUES *et al.*, 2012). It understands that the perception term comes from the act or effect of having a notion or consciousness of reality that surrounds people in the present or past moments and of future projections. People's perceptions of objective reality relate to research conducted "through somebody else's eyes" as in surveys, interviews, or many laboratory experiments. Thus, an assessment of people's perceptions may yield significant insights into the underlying explanation of the phenomenon (MEREDITH *et al.*, 1989).

Therefore, the collected data from interviews took place from December 2019 to June 2021. The individual semi-structured interviews and participant observation were conducted with 119 local residents from Manaus (n=40), Silves (n=38), and Itacoatiara (n=41), selected by convenience sampling . A convenience sampling is a nonprobability sampling strategy where participants are selected based on their accessibility and/or proximity to the research (JAGER; PUTNICK; BORNSTEIN, 2017), as well as, having high representation in the local scale (ANDRADE, 2021). The sample was composed of individuals aged over 18 years for each municipality, and at least five years of residence in the place, including different socioeconomic profiles such as gender, education level, living place, labour situation, etc (Table 2). The participant observation aimed to establish trust relationships by enabling the collection of personal and specific information to complete all data analysis based on perception. Four questions served as a guide for the interview:

I. What do you understand by functions, benefits, and/or services of nature for your well-being?

II. Has there been any change in the environment and/or climate that has affected or is affecting your life and income generation?

III. Do any of these environmental benefits no longer exist or have diminished?

IV. If yes, what do you do to replace this natural provision to maintain your income and maintain or improve your quality of life?

The qualitative data of interviews were transcribed to spreadsheets, and codes were assigned to each response, to generate discrete or binary categorical variables, as well as continuous variables (BARDIN, 2011). The goal was to compose a dataset for ex-posterior multivariate statistical analysis of discrete and/or non-metric variables (HAIR *et al.*, 2010) by canonical correspondence analysis. The justification for using this statistical method is the graphic exploration of the collected data, which allows the recognition of trends in differences or similarities between perceptions.

Table 2 | Framework of interviewee's socioeconomic profile

	Manaus (n=40)	*Itacoatiara (n=41)*	*Silves (n=38)*	*Total (n=119*
Gender (%)				
Female	58	73	29	54
Male	43	27	71	46
Total				**100**
Education level (%)				
Elementary school	30	20	29	26
High school	40	40	63	48
Undergraduate degree	20	40	5	22

	Manaus (n=40)	*Itacoatiara (n=41)*	*Silves (n=38)*	*Total (n=119*
Graduate degree	0	0	0	0
No access	10	0	3	4
Total				**100**
Living place (%)				
Rural	55	5	47	50
Urban	43	90	53	48
Urban/Rural	2	5	0	2
Total				**100**
Labour situation (%)				
Formal income	35	36	35	35
Informal income	65	46	60	57
No occupation	0	18	5	8
Total				**100**

Source: Elaborated by the authors.

4 RESULTS AND DISCUSSION

4.1 THE METROPOLITAN AREA OF MANAUS – BRAZIL PERSPECTIVE

In the Metropolitan Area of Manaus, the environment and climatic variables with the highest perception of change are related to the temperature rise (32%), unbalanced seasons (15%), precipitation rise (11%), and deforestation (10%). Secondly, extreme events (6.5%), wildfires occurrence rise (6.5%), waste quantity increase (4.5%), drought increase (3.5%), accelerating urbanisation (2.5%), precipitation reduction (2%), biodiversity loss (1.5%), and erosion (less 1%), and 4.5% did not perceive changes (Table 3). The local perception about temperature corroborates the temperature data based on the literature, which point to a trend of increasing temperature over the Amazon region, with the MAM reaching about 0.6°C increase, being higher during the dry period, in the last 40 years. The Amazon is also one of the terrestrial environments that registered the greatest rate in the process of global warming from 1980 (IPCC, 2021) due to vegetation losses, wildfires, and urbanisation expansion.

Besides, the beginning of 21st century has had marked episodes of climate extremes to droughts in the Amazon (2000, 2005, 2010, 2015), associated to warming in the tropical North Atlantic and El Niño-Southern Oscillation (Enso) (MARENGO *et al*., 2011; MARENGO; ESPINOZA, 2016). The climate extreme impacts have resulted in losses of agriculture and extractive production; the drought has disturbed the fishing system and health has been compromised due to a lack of freshwater (MARENGO; ESPINOZA, 2016; MARENGO *et al*., 2013; PINHO, 2016; PINHO *et al*., 2015; TOMASELLA *et al*., 2011).

Considering the effects of climate and environmental changes associated with well-being observed in this research (see Figure 2), outside the context of income generation, the variables of wildfires and precipitation rise perceptions showed a high connection to health issues, i.e., increase in diseases and pests (22%), and deforestation perception to thermal discomfort (20%) and effects on tourism activities (1.5%).

The answers indicated greater association to the direct effects on food culture from impacts of unbalanced seasons, drought, and deforestation on agriculture productivity and reduction of fishing

(33%) and supplies (4%) of these products, whereas perception of temperature and extremes events was associated with mobility (8.5%) and infrastructures (11%) (Table 3). As the most common means of transport in the Amazon region is the waterway, residents pointed out that prolonged drought or floods, as extreme events, hinders the access of boats with food and medical supplies to their communities (Figure 2).

Table 3 | Percentage data of perception categories of climate and environmental changes and of their effects

Climate and environmental changes	*Percentage of mentions*
Temperature rise	32.3
Unbalanced seasons	15.4
Precipitation rise	10.9
Deforestation	10.0
Extreme events	6.5
Wildfires rise	6.5
No changes	4.5
Waste increase	4.0
Drought increase	3.5
Accelerating urbanisation	2.5
Precipitation reduction	2.0
Biodiversity loss	1.5
Erosion	0.5
Total	**100**
Effects of climate and environmental changes	*Percentage of mentions*
Agriculture productivity and reduction of fishing	33
Increase in diseases and pests	22
Thermal discomfort	20
Infrastructure problems	11
Mobility problems	9
Supplies	4
Effects on tourism activities	1
Total	**100**

Source: Elaborated by the authors.

The negative effects mentioned by the Amazonian people, which are related to the climate and environmental change perception, were indirect but indicated damage to the ES, which reflected the magnitude of well-being hazards. Respondents also reported that climate change has impacted the ES supply, above all, sources of livelihood and income (source of wild, ornamental, and fishery food) (Figure 2), which influenced the search for self-adaptation strategies.

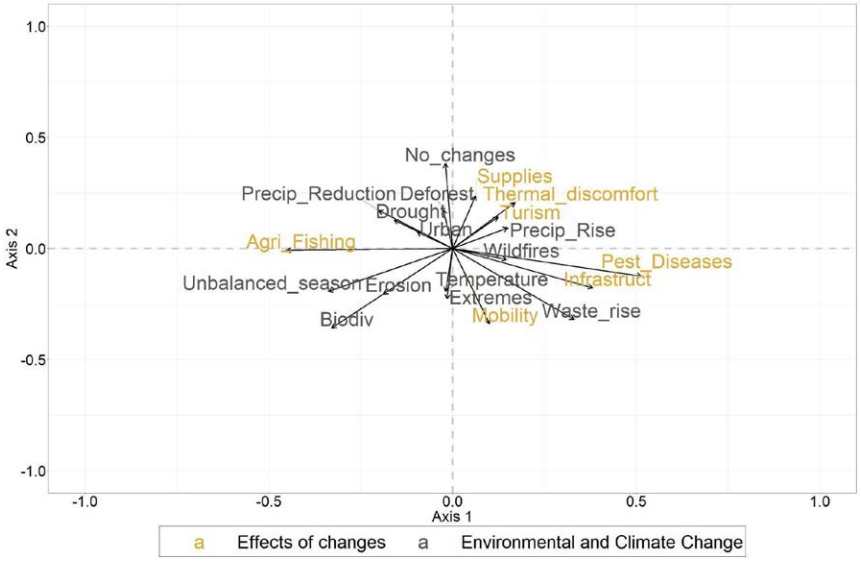

Figure 2 | Canonical correspondence analysis indicating the association of perception categories of climate and environmental change and of its effects

Source: Elaborated by the authors.

Autonomous adaptive measures are behaviours that a population adopts without explicit planning nor the assistance of either institutions (public or private), professionals, or both, all of which are focused on protecting themselves from risks. Thus, autonomous adaptation is related to perception and to the various forms of management processes before or after the occurrence of a disaster or estate change. This is because they arise from the decision-making of the community regarding their experiences (SZLAFSZTEIN; ARAÚJO, 2021).

Based on the interviews, 12 autonomous adaptation strategies (based and not based on ecosystem) applied by this population to minimize the effects of climate change could be classified (Figure 3).

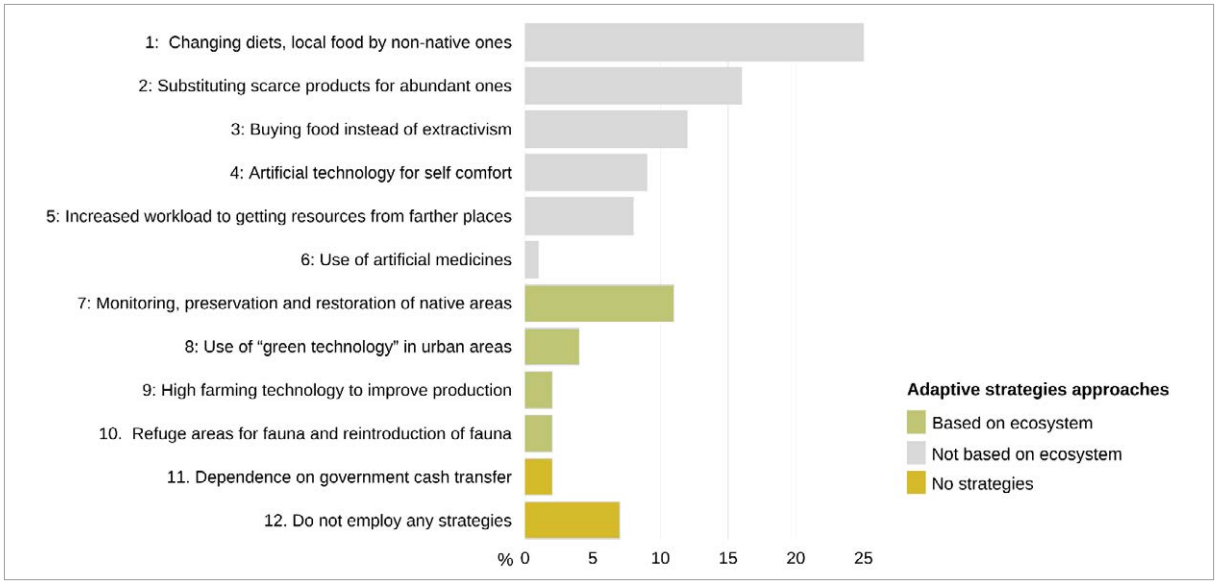

Figure 3 | Adaptation strategies employed by residents

Source: Elaborated by the authors.

The changing diet, with the substitution of local foods for non-native products (26%), is intrinsically related to the conversion or reduction of extractive activities, due to impacts on ES, to agricultural activities (cattle, chicken, pigs, oranges). Given this scenario, the respondents reported a greater

inclusion and consumption of processed foods instead of foods from extraction (12%). This is contrary to a diet historically based on the natural and cultural heritage of the local ecosystem, i.e., CES.

However, of those who still maintained their fishing habits and use of forest products as a source of income and subsistence, around 8% mentioned the increased workload in the search for resources, which are more distant and inaccessible. Thus, another strategy employed is replacing the product that is more difficult to access with more abundant ones (16%), for example exchanging Pirarucu and Tambaqui fish for Branquinha, but generating an increase in pressure on species previously less consumed.

Health consequences of diet changes were also addressed, for example, the increase in health problems related to malnutrition, such as obesity, hypertension, diabetes, and high cholesterol. This indicates that limitations in the supply of healthy foods at affordable prices increase the consumption of ultra-processed foods that are, generally, cheaper, high-sugar and -fat contents, and have low nutritional value, in addition to generating waste with packaging disposal.

The use of fans, air conditioning, and refrigerators was another measure that interviewees reported for reducing thermal discomfort and for food stock (9%). With the heat, the stock of more durable food, in substitution to local delicacies consumed fresh, generates greater use of electric energy and increased costs.

Although most adaptation strategies follow the globalization logic of commodity production and consumption, this research mentions other adaptation alternatives based on ecosystem, denoting community's interest in strengthening some cultural economic aspects of the Amazon region. Therefore, of the 12 mentioned adaptations, four have an approach based on ecosystem, which embed three macro strategies described in Table 4.

Table 4 | The three actions as autonomous adaptation strategies for climate impacts on Ecosystem Services in the Metropolitan Area of Manaus (state of Amazonas), using ecosystem-based approaches

Surveillance strategy	*Preservation strategy*	*Regulatory strategy*
Voluntary inspection in which the residents themselves monitor possible environmental and climatic threats, for example, stopping fishing activity during the reproductive period of fish species in the region "defeso" (closed season)	Respect for the closed season, reduced extraction of native trees and restoration of local vegetation in their own backyards or rural areas	To regulate the local climate in urban-rural areas - Planting trees (4%); - Reintroducing wild animals into their habitat (2%); - Intensive farming and use of technology in production (2%)
- Monitoring, preservation, and restoration of native areas (11%)		

Source: Elaborated by the authors.

Although many residents used their own ways, inconsistent with the characteristics of the ecosystem, for adapting to the ES decline, a relevant number of people showed engagement in environmental movements on a local scale. This demonstrates that the social dynamics of Amazonian communities is not passive to climate change, which reinforces the need for public policies to consider the ES management, preservation, and conservation valuing the cultural, and not only the material, dimension of the territory.

4.2 LESSONS LEARNED WITH THE CASE STUDY OF BRAZIL

Since collective goals driven by an individual's belief system are behind personal choices, managing food consumption is a crucial component of public policy planning with greater respect for local cultural diversity. This point to the need for adaptive solutions that reflect multiple worldviews and more collectivist adaptive strategies to overcome climate change challenges.

As pointed out by Niles *et al*. (2017), a survey of this type regarding people's cultural perception must be used by decision makers in the public policy sphere to influence adaptation and mitigating initiatives for climate change impacts. Especially if the adaptation strategies employed by residents reinforce a land use for agriculture and livestock, which is one of sectors that contribute the most to deforestation, consequently to Brazil's GHG emissions, mainly of the Amazon biome (SEEG, 2021).

Food security is evidently threatened in Brazil in regions where, historically, the population would have access to food in sufficient quantity and quality for a healthy life. In this case study, the perceptions indicate the impacts in the cultivation, hunting, and consumption in the variety of species and natural sources of food.

Notably, access to food depends on purchasing power and that a substantial portion of peri-urban populations is low-income in Brazil, for this reason it is essential to include the most vulnerable people in local environmental policies (HOFFMAN, 1995).

5 FINAL CONSIDERATIONS

Generally, the case study of one peri-urban community from a country of the Global South evinced the interrelationship between climate and environmental changes and cultural ecosystem services.

Therefore, the research tried to fill a gap in the literature on the approach of cultural ecosystem services at the intersection with other categories by integrating information about services related to provisioning and regulation services in the Amazon. The evaluating interface among the ES categories is rich in complementing the design of forest management and conservation strategies by analysing different values and trade-offs at the landscape scale based on local ecosystem services. Moreover, this article identified how local communities are adapting themselves to climate change by integrating disrupted aspects of cultural and natural heritage.

This study examines the diversity of adaptations to climate change and their effects as a cultural phenomenon. Note that the choice of an analysis on a micro scale, in which the range of actors, contexts, and interests is less diffuse, does not mean that it is not socially representative of the conditions that increase or restrict adaptive capacity (ADGER *et al*., 2009). The perception of climate risks generated adaptive responses that triggered changes in that regional socioeconomic structure.

Thus, the intensification of regulations at the global level normalizes the rhetoric of the international community. Nevertheless, local communities continue to live in territories, which are disparate in terms of economic resources and political representation power when compared with the countries of the Global North, which sovereign in the debate on climate change. These worldviews prevalent in politics and economics are broken down at regional, national, and local levels and adapted to multiple interests, not always suited to the realities and needs of their citizens.

Cultural processes of meaning-making remain marginalized. Although difficult to value, these intangible values may help to measure the costs and risks associated with environmental degradation as well as implement environmental policies that really attend to people needs and expectations.

While the links between culture, values, nature, well-being, and politics are complex and the plural and fluid quality of their meanings is difficult to grasp, a more inclusive and deliberative approach to environmental policy requires a cultural change within institutions. This is because critical reflection on what shapes our individual and collective values is as essential as efforts to capture the value of ecosystems. The results indicate that these approaches are relevant elements to formulate more adequate public policies and better physical-spatial planning to manage environmental ecosystems and better manage forests and land use.

Finally, integrating Cultural Ecosystem Services in the assessment and governance of common resources, which may challenge the traditional market approaches aimed at the interests of a few, is needed.

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NOTES

1 | For culture, or a system of collective ideas, comprises notions and social norms of a group on what are acceptable, correct, and morally adjusted behaviours (PFAU-EFFINGER, 2005).

2 | Perceptions about environmental and climate change can also be analysed by individualistic or collectivist cultural positions that stimulate and shape the relationship between humans and risks (ADGER *et al*., 2009).

3 | Curupira is a figure from Brazilian folklore, characterized as an entity of the woods that manifests itself in the form of a boy with long red hair whose main characteristic is having feet turned backwards.

4 | Peri-urban areas are zones of transition from rural to urban land uses located between the outer limits of urban and regional centres and the rural environment. The boundaries of peri-urban areas are porous and transitory as urban development extends into rural and industrial land. Source: Unesco. Available on: https://en.unesco.org/events/peri-urban-landscapes-water-food-and-environmental-security

5 | The Manaus Free Trade Zone (ZFM) was created by Decree-Law no. 288, of 1967, as free trade area, beneficiary of tax incentives, with the objective of occupying the Amazonian territory in 2013, the ZFM tax incentives were extended until 2073. That is, a tax incentive program has been in existence for more than half a century and is expected to last another half century. However, its effectiveness, costs, and benefits are still studied. Source: FGV Study. Zona Franca de Manaus: Impactos, Efetividade e Oportunidades. Available on: https://eesp.fgv.br/sites/eesp.fgv.br/files/estudos_fgv_zonafranca_manaus_abril_2019v2.pdf

6 | This research was conducted in accordance with the ethics commitments

REFERENCES

ADGER, W. *et al*. Are there social limits to adaptation to climate change? **Climatic change**, v. 93, n. 3, p. 335-354, 2009.

ADGER, W. *et al*. Cultural dimensions of climate change impacts and adaptation. **Nature Climate Change**, v. 3, n. 2, p. 112-117, 2013.

ANDRADE, C. The Inconvenient Truth about Convenience and Purposive Samples. **Indian Journal of Psychological Medicine**, v. 43, n. 1, p. 86–88, 17 jan. 2021. DOI 10.1177/0253717620977000

BARDIN, L. **Análise de conteúdo**. São Paulo: São Paulo: Edições, 2011.

BRONDIZIO, E. S. *et al*. Re-conceptualizing the Anthropocene: a call for collaboration. **Global Environmental Change**, v. 39, p. 318-327, 2016. DOI 10.1016/j.gloenvcha.2016.02.006.

BURKHARD, B. *et al*. Ecosystem service potentials, flows and demands-concepts for spatial localisation, indication and quantification. **Landscape Online**, v. 34, n. 1, p. 1–32, 2014. DOI 10.3097/LO.201434

CICES. **The Common International Classification of Ecosystem Services**. (Cices) V5.1. Available at: https://cices.eu/. Accessed on: june 17. 2022.

COMBERTI, C. *et al*. Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. **Global Environmental Change**, v. 34, p. 247-262, 2015. DOI 10.1016/j.gloenvcha.2015.07.007

DAILY, G. C. **Nature's services**: societal dependence on natural ecosystems (1997). Yale University Press, 2013.

DAVIDSON, E. A. *et al*. The Amazon basin in transition. **Nature**, v. 481, p. 321–328, 2012. DOI 10.1038/nature10717

DELANG, C. O. The Second Phase of the Grain for Green Program: adapting the largest reforestation program in the world to the new conditions in rural China. **Environmental management**, v. 64, n. 3, p. 303-312, 2019.

DOUGLAS, M. **Risk and blame**. Essays in cultural theory. London and New York: Routledge, 1992.

DOUGLAS, M.; WILDAVSKY, A. Introduction: can we know the risks we face? *In:* **Risk and culture**. University of California Press, p. 1-15. 1983.

FISCHER, A. P. Adapting and coping with climate change in temperate forests. **Global Environmental Change**, v. 54, p. 160–171, jan. 2019.

FÜSSEL, H.-M. Adaptation planning for climate change: concepts, assessment approaches, and key lessons. **Sustainability Science**, v. 2, n. 2, p. 265–275, 21 sept. 2007. DOI 10.1007/s11625-007-0032-y.

GIDDENS, A. **As consequências da Modernidade**. São Paulo: Ed. Unesp, 1991.

HAIR, J. *et al*. **Multivariate Data Analysis**: a global perspective. 7th. ed. [s.l.] Pearson, 2010.

IBGE. **Censo 2017**. Available at: https://biblioteca.ibge.gov.br/biblioteca-catalogo.html?id=442616&view=detalhes. Accessed on: feb. 4. 2022.

IBGE. **Panorama das Cidades 2019**. Available at: https://cidades.ibge.gov.br/. Accessed on: feb. 27. 2023.

IPCC. **AR5 Climate Change 2014**: impacts, adaptation, and vulnerability. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change. [s.l.] Cambridge University Press, 2014.

IPCC. **Climate Change 2021**: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. United Kingdom and New York, NY, USA: Cambridge University Press, Cambridge, 2021.

JAGER, J.; PUTNICK, D. L.; BORNSTEIN, M. H. II. More Than Just Convenient: the scientific merits of homogeneous convenience samples. **Monographs of the Society for Research in Child Development**, v. 82, n. 2, p. 13–30, june 2017. DOI 10.1111/mono.12296.

KADYKALO, A. N. *et al*. Disentangling 'ecosystem services' and 'nature's contributions to people'. **Ecosystems and People**, v. 15, n. 1, p. 269-287, 2019.

MARENGO, J. A. *et al*. The drought of 2010 in the context of historical droughts in the Amazon region. **Geophysical Research Letters**, v. 38, n. 12, p. n/a-n/a, jun. 2011. DOI 10.1029/2011GL047436

MARENGO, J. A. *et al*. Recent Extremes of Drought and Flooding in Amazonia: vulnerabilities and human adaptation. **American Journal of Climate Change**, v. 02, n. 02, p. 87–96, 2013. DOI 10.4236/ajcc.2013.22009

MARENGO, J. A.; ESPINOZA, J. C. Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. **International Journal of Climatology**, v. 36, n. 3, p. 1033–1050, mar. 2016. DOI 10.1002/joc.4420

MEREDITH, J. R. *et al*. Alternative research paradigms in operations. **Journal of Operations Management**, v. 8, n. 4, p. 297–326, out. 1989. DOI 10.1016/0272-6963(89)90033-8

MILLER, J. Is green the new red?: the role of religion in creating a sustainable China. **Nature and Culture**, v. 8, n. 3, p. 249-264, 2013.

NILES, M. T. *et al*. **Climate change and food systems**: assessing impacts and opportunities. 2017.

NOLL, B.; FILATOVA, T.; NEED, A. How does private adaptation motivation to climate change vary across cultures? Evidence from a meta-analysis. **International Journal of Disaster Risk Reduction**, 2020.

OTTO, I. M. *et al*. **Social tipping dynamics for stabilizing Earth's climate by 2050**. Proceedings of the National Academy of Sciences of the United States of America, v. 117, n. 5, p. 2354–2365, 2020. DOI 10.1073/pnas.1900577117

PFAU-EFFINGER, B. Culture and welfare state policies: reflections on a complex interrelation. **Journal of social policy**, v. 34, n. 1, p. 3-20, 2005.

PINHO, P. F.; MARENGO, J. A.; SMITH, M. S. Complex socio-ecological dynamics driven by extreme events in the Amazon. **Regional Environmental Change**, v. 15, n. 4, p. 643–655, 14 apr. 2015. DOI 10.1007/s10113-014-0659-z

PINHO, P. F.; MARENGO, J. A.; SMITH, M. S. Watching Brazil but Missing the Story: an Amazonian inferno. S**pecial issue on Environmental Justice and Climate Change in Latin America LASAFORUM**, v. XLVIII, n. 4, p. 21–25, 2016.

PLIENINGER, T. *et al*. Assessing, mapping, and quantifying cultural ecosystem services at community level. **Land use policy**, v. 33, p. 118-129, 2013.

PNUD. Ranking IDHM dos municípios brasileiros. Available at: https://www.br.undp.org/content/brazil/pt/home/idh0/rankings/idhm-municipios-2010.html. Accessed on: may 08. 2021.

REID, W. V. *et al*. Ecosystems and human well-being-Synthesis: a report of the **Millennium Ecosystem Assessment**. Island Press, 2005.

RUSSELL, R. *et al*. Humans and nature: how knowing and experiencing nature affect well-being. A**nnual review of environment and resources**, v. 38, p. 473-502, 2013.

SCHOR, T.; MARINHO, T. P. Ciclos econômicos e periodização da rede urbana no Amazonas – Brasil: as cidades de Parintins e Itacoatiara de 1655 a 2010. **Revista do Instituto de Estudos Brasileiros**, n. 56, p. 229-258, 2013.

SEEG. **Análise das Emissões Brasileiras de GEE e suas implicações para as metas do Brasil: 1970-2019**. São Paulo: Observatório do Clima, 2021.

SEIXAS, S. R. DA C. *et al*. Percepção de pescadores e maricultores sobre mudanças ambientais globais, no litoral Norte Paulista, São Paulo, Brasil. **Journal of Integrated Coastal Zone Management**, v. 14, n. 1, p. 51–64, 2014.

SEIXAS, S. R. DA C.; NUNES, R. J. Subjectivity in a context of environmental change: opening new dialogues in mental health research. **Subjectivity**, v. 10, n. 3, p. 294–312, 11 set. 2017. DOI 10.1057/s41286-017-0032-z

SEIXAS, S. R. DA C.; NUNES, R. J. Percepção de pescadores e maricultores sobre mudanças ambientais globais, no litoral Norte Paulista, São Paulo, Brasil. **Journal of Integrated Coastal Zone Management**, v. 14, n. 1, p. 51-64, 2014. Available at: https://doi.org/10.1057/s41286-017-0032-z.

SZLAFSZTEIN, C. F.; ARAÚJO, A. N. B. DE. Autonomous flood adaptation measures in Amazonian cities (Belém, Brazil). **Natural Hazards**, v. 108, n. 1, p. 1069–1087, 4 aug. 2021. DOI 10.1007/s11069-021-04720-x

TOMASELLA, J. *et al*. The droughts of 1996-1997 and 2004-2005 in Amazonia: hydrological response in the river main-stem. **Hydrological Processes**, v. 25, n. 8, p. 1228–1242, 15 apr. 2011. DOI 10.1002/hyp.7889

Identification of extreme rainfall events and disasters triggered by rain in the city of Petrópolis-RJ

Identificação de eventos extremos de precipitação e desastres deflagrados por chuvas no município de Petrópolis-RJ

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ARTICLE- VARIA

ABSTRACT

The municipality of Petrópolis/RJ/Brazil is prone to extreme rainfall events that cause damage and direct and indirect economic losses. In order to verify the increase or not of these events, this study evaluates the temporal pattern of rainfall in the municipality (1976-2022), identifying whether the event that occurred in 2022 can be considered an extreme event, as well as the relationship between rainfall and impact intensity, in terms of damage and losses triggered. The accumulated rainfall over 24 hours (RX1), over 5 days (RX5), the 95th and 99th percentiles (R95 and R99), the Rainfall Anomaly Index (RAI) and trend analyses using the Mann-Kendall method, as well as loss and damage data were then

calculated. The results did not indicate a trend towards an increase in precipitation extremes, although they did confirm the February 2022 event as an extreme event, which stood out as the largest within the historical series analysed.

Keywords: Precipitation extremes. Petrópolis-RJ. Rain-related disasters. Occurrence of disasters.

RESUMO

O município de Petrópolis-RJ, Brasil, está exposto a eventos extremos de precipitação, que resultam em danos e perdas econômicas diretas e indiretas. Para verificar o aumento ou não desses eventos, o objetivo foi avaliar o padrão temporal das chuvas no município (1976-2022), identificando se o evento ocorrido em 2022 pode ser considerado um evento extremo, bem como a relação entre pluviometria e intensidade do impacto, em termos dos danos e perdas deflagrados. Foram então calculados os acumulados de precipitação em 24 horas (RX1), em 5 dias (RX5), percentis 95 e 99 (R95 e R99), Índice de Anomalia de Chuvas (IAC) e análises de tendência pelo método Mann-Kendall, bem como dados de perdas e danos. Os resultados não indicaram viés de aumento dos extremos de precipitação, embora tenha confirmado o evento ocorrido em fevereiro de 2022 como um evento extremo, o qual se configurou como o maior da série histórica analisada.

Palavras-chave: Extremos de precipitação. Petrópolis-RJ. Desastres relacionados à chuva. Ocorrência de desastres.

1 INTRODUCTION

Since the 1990s, reports from the Intergovernmental Panel on Climate Change (IPCC) have been published regarding climate-related changes and expectations on a global scale, including significant alterations in the magnitude and frequency of extreme meteorological phenomena (IPCC, 2012, 2021). The most recent report also indicates an increased impact on ecosystems, populations, and settlements due to anthropogenic climate change (IPCC, 2022).

To comprehend the damages associated with extreme meteorological events, it is imperative first to recognise these occurrences. The World Meteorological Organization (WMO) defines them as meteorological events that deviate significantly from average conditions, considering a historical series of at least 20 years, and having the potential to pose hazards or significant impacts on human activities and the environment (IPCC, 2022).

Given the vulnerabilities inherent in the territory and the predisposition of exposed elements to suffer losses and damages, extreme meteorological events can trigger disasters of varying severity (COUTINHO *et al*., 2020; DEBORTOLI *et al*., 2017; IPCC, 2012; LAHSEN; RIBOT, 2020).

In tropical regions, there is evidence of an increasing frequency and intensity of heavy rainfall events, resulting in various impacts amplified by the limited adaptive capacity of developing countries (PRABHAKAR *et al*., 2009).

In Brazil, a significant portion of disaster occurrences is caused by phenomena triggered by rainfall, such as flash floods, inundations, and mass movements (PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS, 2014). Considering the projected rise in average air temperatures due to climate change, an expectation of more frequent extreme rainfall events emerges, thereby increasing the likelihood of disasters. To examine this hypothesis and formulate adaptation strategies for the country, it is essential to monitor extreme events within the territory.

The mountainous region of the state of Rio de Janeiro serves as an example of a city experiencing cascading effects from intense precipitation. In January 2011, a disaster resulted in damages and losses in at least seven municipalities, including Petrópolis, with an approximate toll of 947 casualties (DOURADO *et al*., 2012).

Petrópolis is recurrently affected by heavy rainfall and has records of disasters dating back to 1950 (ASSUMPÇÃO, 2015). More recently, between January and March 2022, three episodes of intense rainfall associated with Local Convective Storms caused severe impacts on the population. The most severe event occurred on February 15, resulting in the death of at least 234 people (ALCÂNTARA *et al*., 2022; GRUBERTT, 2022).

Considering these alarming figures, inquiries arise regarding measures that could be undertaken to mitigate the risk of rainfall-triggered disasters in this region. Recognising that risk knowledge is one of the four fundamental pillars for disaster risk reduction, the objective of this study was to analyse the temporal pattern of extreme rainfall events (threat), determining whether the event in 2022 can indeed be classified as extreme, as well as exploring the relationship between rainfall and impact intensity in terms of damages and losses incurred in the municipality

2 MATERIALS AND METHODS

2.1 STUDY AREA

The municipality of Petrópolis is situated at the geographic coordinates of 22°30'17" South latitude and 43°10'42" West longitude, within the Serrana Region of the State of Rio de Janeiro. As indicated by the Geotechnical Suitability Map issued by the Geological Survey of the State of Rio de Janeiro, the combined area exhibiting moderate and high susceptibility to mass movements accounts for 64.06% of the municipality.

According to data from the year 2022, Petrópolis is estimated to harbour a population of 278,881 inhabitants, boasting a demographic density of 352.50 individuals per square kilometre (IBGE, 2022). Over the course of eight decades, the municipality has experienced a fourfold population increase, surging from 75.4 thousand inhabitants in 1940 to 278.881 thousand inhabitants in 2022 (IBGE, 1940, 2022).

As of the 2010 Census (the latest data available at the time of this publication), the population of Petrópolis stood at 295,917 individuals, of which 72,070 individuals (equivalent to 24.35%) resided within areas deemed prone to risks, distributed across 22,298 households (CEMADEN; IBGE, 2018). Despite this circumstance, the municipality displayed a Municipal Human Development Index (IDHM) of 0.745 (IBGE, 2010), signifying a level considered high and falling within the national average for Brazil, where the national HDI stood at 0.727. According to the Petrópolis municipal administration, the current IDHM for the locality has risen to 0.804, even in the face of adverse events encountered within the past decade, while the national figure for Brazil has declined to 0.724.

2.2 DATA

The rainfall data used in this work come from the automatic measurement station Xerém, belonging to the Inmet network, located in Duque de Caxias (-43° 30' 14.004" S, 22° 55' 33.996" W). This station is the closest to the study area (approximately 15 km) and has the longest historical series. In a complementary way, precipitation data from the São Sebastião station, belonging to the National Center for Monitoring and Alerts of Natural Disasters (Cemaden), located in the municipality of Petrópolis, were also used.

The analysis period of this study was established between 1976 and 2022 due to the availability of the largest amount of data in this interval. Although it is a long period, it is important to highlight that the data from the meteorological stations present some failures, which were corrected by using interpolated average rainfall values from the data of the Climate Hazards Group InfraRed Precipitation

with Station data – Chirps (FUNK *et al*., 2015) and the Merge Product of the Center for Weather Forecasting and Climate Studies (MERGE; ROZANTE *et al*., 2010). These rainfall data sets have a spatial resolution of approximately 5 km and 10 km, respectively. A similar methodology was developed by Costa *et al*. (2019), who proposed to validate precipitation data in Brazil using Chirps data; Costa identified a compatibility of 95.4% between Inmet and Chirps data, which legitimises the use of these data to complete the gaps in the historical series selected for this study. Thus, from precipitation data from the meteorological stations of Xerém and São Sebastião and complemented by Chirps and Merge data, a time series of daily precipitation data from 1976 to 2022 was constructed.

2.3 METHODS

2.3.1 CLIMATE INDICES

The indices calculated to help understand the temporal pattern of precipitation in the municipality of Petrópolis and identify the extreme values were:

- Pt - Annual total precipitation
- Pmed - Annual average precipitation
- Ptri - Sum of the quarterly moving average
- R95 - Number of days when daily precipitation was greater than 95% of the precipitations of the period
- R99 - Number of days when daily precipitation was greater than 99% of the precipitations of the period
- RX1 - Maximum annual value in one day of precipitation
- RX5 - Maximum precipitation value in five consecutive days

2.3.2 RAINFALL ANOMALY INDEX

In addition to the indices presented, the Rainfall Anomaly Index (IAC) was also calculated, which considers the average of the ten highest rainfall events that occurred within the analysis period, as well as the average of the ten lowest, with positive anomalies being those above the average and negative anomalies being those below the average. The IAC is classified in terms of dry and wet periods, as proposed by Rooy (1965) and adapted by Freitas (2005). The anomalies can be expressed as follows:

Positive anomalies

$$IAC = 3\left[\frac{(N - \underline{N})}{(\underline{M} - \underline{N})}\right]$$

Negative Anomalies

$$IAC = -3\left[\frac{(N - \underline{N})}{(\underline{X} - \underline{N})}\right]$$

Where N is the monthly precipitation, _N is the average of the series, _M is the average of the ten highest precipitations, and _X is the average of the ten lowest precipitations. Still, according to the index, the rainfall classification varies from extremely rainy to extremely dry.

2.3.3 MANN-KENDALL TEST

The Mann-Kendall test (KENDALL, 1975; MANN, 1945) is a nonparametric test suggested by the World Meteorological Organization (WMO) to verify if the series have statistically significant temporal trends and has been used with great efficiency. Thus, for the trend to be confirmed, the p-value must be less than 0.05%, representing a confidence of 95%. Thus, the test was applied to identify possible trends in the temporal pattern of annual precipitation and the indices RX1, RX5 and IAC.

2.3.4 METHODOLOGIES USED TO CALCULATE LOSSES AND DAMAGES

After analysing the threat of extreme rainfall events, we performed analyses of the damage and losses caused by rain-related disasters in the municipality of Petrópolis. These analyses were based on data from the Integrated Disaster Information System (S2iD), which incorporates several products from the National Secretariat for Protection and Civil Defense – Sedec (BRAZIL, 2022). The historical series used corresponds to the period of data available for Petrópolis, 2001 - 2022. The typologies used in the classification of disasters in this database follow the Brazilian Disaster Coding – Cobrade. In S2iD, the impact data are grouped into four categories: human damage (DH), material damage (DM), public losses (PEPL) and private losses (PEPR), the same ones used in the present analysis. The DM, PEPL, and PEPR values received monetary correction in December 2022 and were synthesised in a single variable representing the total damage and losses (D&L: damage and losses in English), converted to US dollars. A summary of the methodological steps developed can be seen in Figure 1.

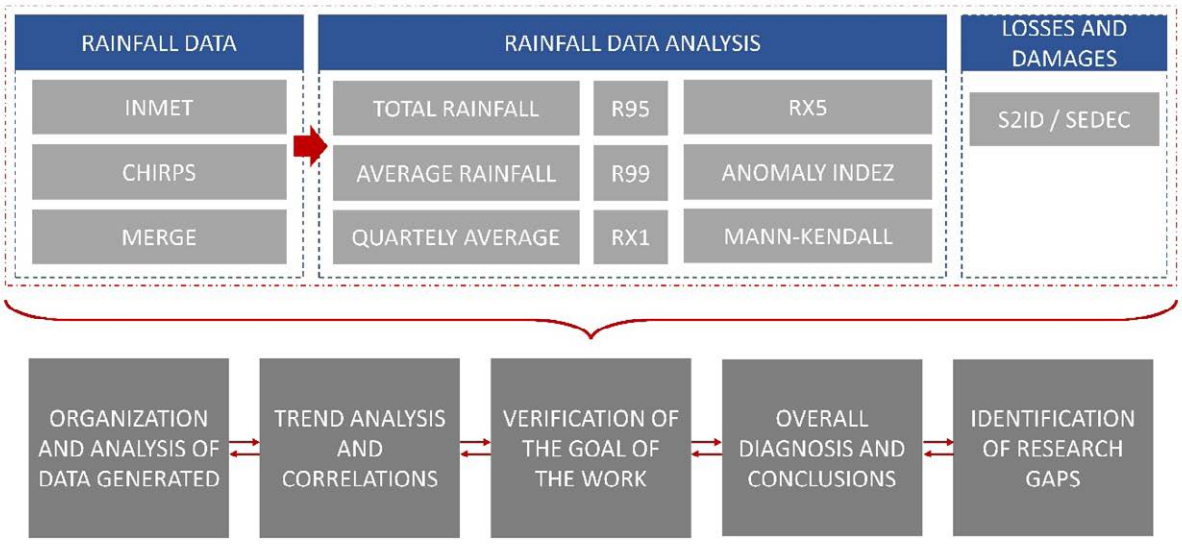

Figure 1 | Infographic with methodological steps

Source: The authors.

3 RESULTS AND DISCUSSION

3.1 ANALYSIS OF THE TEMPORAL PATTERN OF EXTREME PRECIPITATION EVENTS

In the period from 1976 to 2022, the average monthly rainfall remained more or less constant around the multi-year monthly average (Figure 2), in a standard deviation range of 77 mm, except for the year 1999, with a negative extreme of 5.5 mm (one time lower than the average) and 2022, with a positive extreme of 358.6 (three times the average).

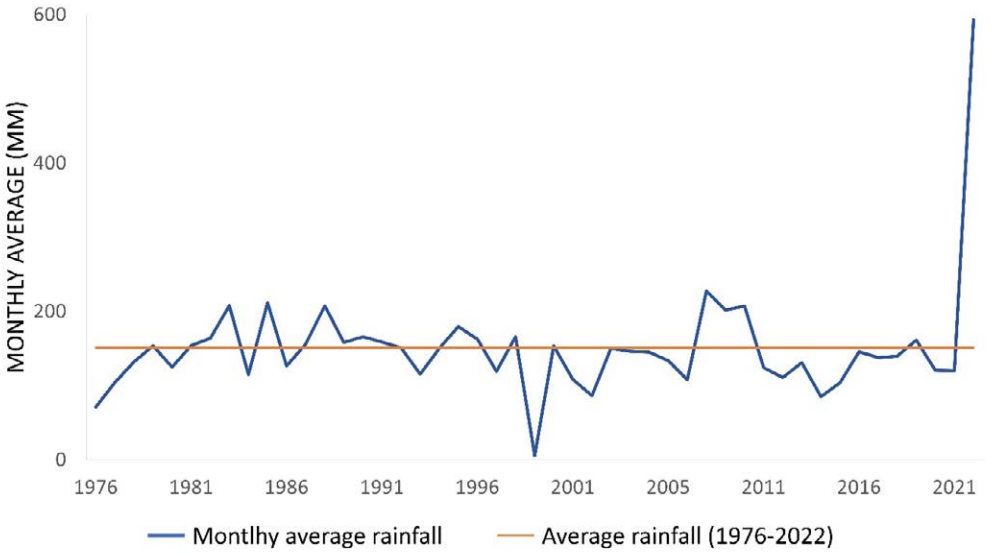

Figure 2 | Average monthly accumulated and multi-year monthly precipitation average in Petrópolis

Source: The authors.

The results of the Mann-Kendall test indicated a trend of reduction in rainfall volume over the period but did not show statistical significance. This result corroborates the analysis performed by Silva *et al*. (2023), who, when analysing the climatic trend of Petrópolis, did not find the presence of a trend by the Ljung-Box and Mann-Kendall tests and diverges from the analyses of Oscar Júnior (2021) that indicates that there is a statistically significant trend of increase in monthly rainfall in Petrópolis, although the authors used different time series.

The concentration of rain in certain periods of the year was also evaluated for the series. The analysis of quarterly moving averages of precipitation indicated that the quarter November - December - January had the highest monthly average of rainfall, followed by the quarter December - January - February, preceding the rainy season. In this season, the two events with the highest number of victims occurred: January 11, 2011, and February 15, 2022. According to Silva *et al*. (2020), rainfall accumulation between October and March occurs due to the meteorological system South Atlantic Convergence Zone, which acts strongly in the region, generating local storms. Although they are not conclusive about the motivation of the events, these results indicate that prevention and response actions to possible extreme precipitation events must precede the beginning of the rainy season in the region, in addition to requiring a greater focus on medium and long-term actions.

Beck (2023) points out that there are already actions in this direction under development in the municipality, such as a study for creating barriers to contain mass movements and the Municipal Risk Reduction Plan, both as part of a plan to make the city more resilient. Although extreme events have unique characteristics, they can be part of regional events or even be triggered by specific characteristics of the place, so it is necessary to have a consolidated diagnosis of the area that allows effective actions in favour of resilience and involving not only pluviometric analyses. In this sense, Alcântara *et al*. (2023) indicate that other factors, such as the removal of native vegetation, population growth in areas with slopes between 45-60º and lack of urban planning, contribute significantly to the occurrence of disasters in the municipality.

Still, regarding the analysis of precipitation data, the extremes of rainfall were also evaluated using the RX1 index, which returns the maximum precipitation values in 24 hours for each year (Figure 3). The highest rainfall volume of the entire time series occurred on March 21, 2022, with a total of 358.6 mm, followed by February 12, 1998, with 301.4 mm. The Mann-Kendall test did not show a significant change trend in the maximum rainfall value.

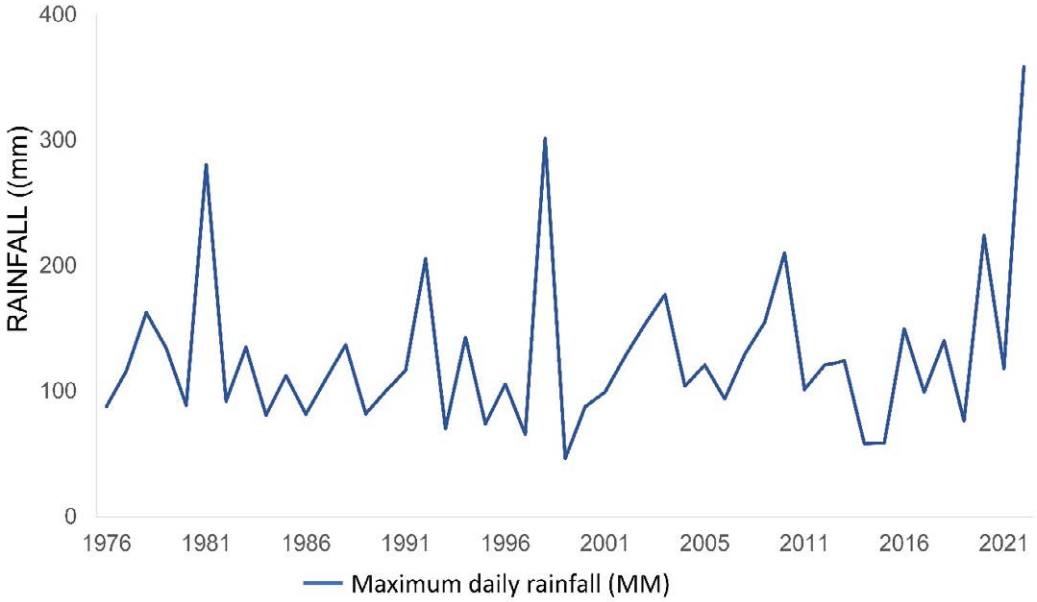

Figure 3 | Temporal evolution of the RX1 index for the municipality of Petrópolis

Source: The authors.

It should be noted that, concerning the daily data, the rain gauge installed by Cemaden in the São Sebastião neighbourhood, the main neighbourhood affected by the rains of 2022, recorded 260 mm of accumulated precipitation in two and a half hours on February 15, 2022, and 476.8 mm accumulated in 24 hours between March 20 and 21, while the rain gauge in the Quitandinha neighbourhood, about 3 km away, marked 200 mm, indicating that the event may have been extremely concentrated.

Unfortunately, due to the reduced number of rain gauges in the municipality, including a historical series of them, it is impossible to confirm whether this concentration existed or is recurrent, as the data indicate. Despite this, following this line, Oscar Júnior (2021) indicated a trend of reduction in the number of rainy days with an increase in the concentration of rainfall in daily events or up to five consecutive days for the municipality. Regarding the maximum volume of rainfall accumulated in five days (RX5), it was not possible to verify a trend of increase in the number of rainy days by the Mann-Kendall test. When analysing the 95th percentile of the historical series, an average of 17 rainy days per year above the average of the series is observed (Figure 4).

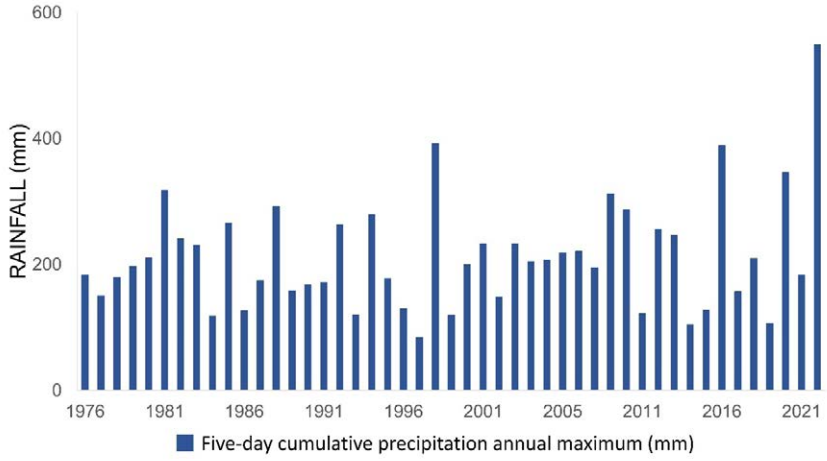

Figure 4 | Temporal (annual) distribution of the RX5 index in the city of Petrópolis

Source: The authors.

The 95th percentile for the maximum values of accumulated rainfall in five days (RX5) presents the value of 376.1 mm, and the 99th percentile shows 477.07 mm, both below the value of rainfall accumulated in five days in 2022, which in just one day the precipitation was 358.6 mm. This result confirms the exceptionality of the event in February 2022, which allows its classification as an extreme event.

Still aiming to understand the dynamics of rainfall distribution, the Rainfall Anomaly Index (IAC) calculated pointed out 26 extremely rainy, very rainy or rainy years, 26 dry and two very dry years (Figure 5). However, it was not possible to correlate whether the years with the highest positive anomalies resulted in a higher number of victims or even any trend (by the Mann-Kendall test) that the number of positive or negative anomalies is increasing, it was possible to observe that the year 2022 had the highest positive anomaly of the period, further confirming the exceptionality of the event.

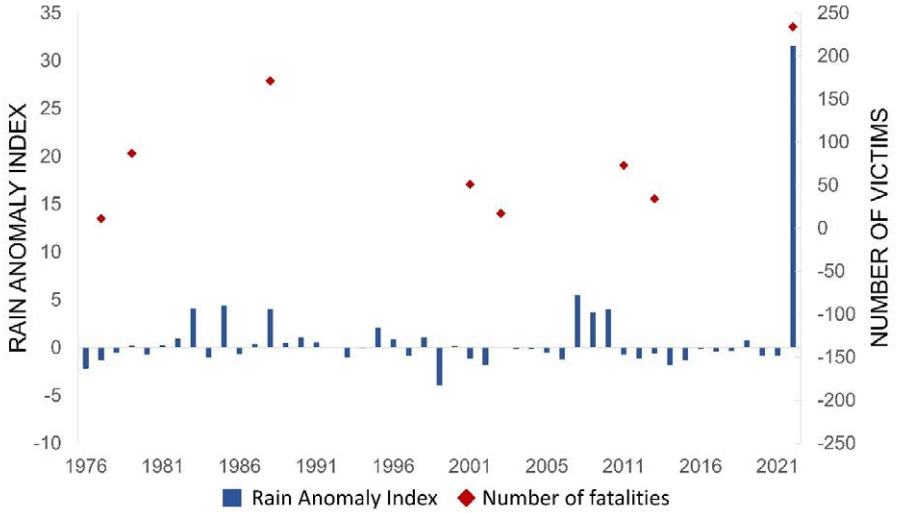

Figure 5 | Climate Anomaly Index (CAI) and years with fatalities in the city of Petrópolis

Source: The authors.

The occurrence of anomalies may be associated with the presence of other meteorological events, such as the South Atlantic Convergence Zone (SACZ) or even Frontal Systems, which enhance rainfall, causing river flooding, facilitating the occurrence of landslides and mass movements and, consequently, loss of lives (SILVA *et al*., 2020), recurrent events in the municipality of Petrópolis. In the specific case of the event in 2022, Alcântara *et al*. (2023) indicate that the SACZ was positioned over Rio de Janeiro, favouring atmospheric convection and consequent meteorological instability.

The data presented throughout the work corroborate studies that indicate that this region has undergone a change in the climatic scenario that, although it does not significantly affect the total annual rainfall amount, changes the distribution, leading to an increase in the probability of occurrence of extreme precipitation events, more specifically an increase in cases of large volumes of rain in a very short time (OSCAR JÚNIOR, 2021; SILVA *et al*., 2020; SILVA *et al*., 2023). With the present analysis, it was not possible to correlate whether the accumulated rainfall influenced the number of fatal victims, considering that susceptibility is the sum of several parameters and that Petrópolis presents a scenario of multiple hazards. However, it is possible to affirm that deaths occurred because of rainfall events. To perform this correlation, deepening the analyses and including other factors, such as slope, land use, and occupation, would be necessary. In this sense, Alcântara *et al*. (2023) affirm that the rates and the way urbanisation occurred in Petrópolis surpass climatic characteristics as inducers of landslides and, consequently, disasters since most of the constructions are in areas with slopes greater than 20%.

Urbanisation affects and is directly affected by the concentration of rainfall volume, influencing the definition of suitable places for housing, for example. Consequently, it generates concern regarding the municipality's capacity to respond to high rainfall concentrations in a short period. Although the Municipal Government of Petrópolis has implemented actions such as the Alert and Alarm System, according to the Municipal Risk Reduction Plan, no physical interventions were carried out to improve water drainage during rainy events (PREFEITURA MUNICIPAL DE PETRÓPOLIS, 2017), which enhances the negative effect of rainfall.

3.2 ANALYSIS OF DAMAGES AND LOSSES RELATED TO RAIN

Based on the historical series of disaster occurrences related to the municipality of Petrópolis, period 2001 - 2022, it is observed that the typologies of threats with the highest number of occurrences are soil/rock landslides, flash floods and heavy rains. The distribution of these events occurred between October (the beginning of the rainy season) and April (the end of the rainy season), coinciding with the months that returned higher rainfall indices in the analysis (Figure 6). The data corroborate a study by Torres *et al*. (2020), which indicates that the number of landslides has shown an increasing trend in the municipality of Petrópolis, directly related to high precipitation values, especially when the accumulated exceeds 48 or 72h.

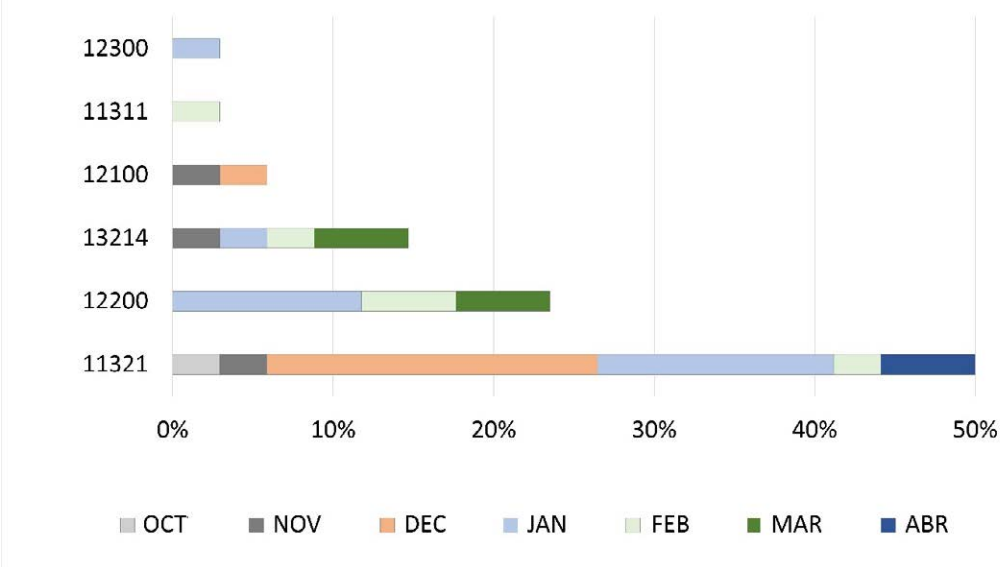

Figure 6 | Monthly distribution of disasters by threat typology in Petrópolis. 12300 Flooding (1); 11311 Rockfall (1); 12100 Inundation (2); 13214 Heavy Rain (5); 12200 Flash Flood (8); 11321 Soil and/or Rock Landslide (17).

Source: The authors.

Human damage (DH) refers to the impact on people; in the database, it is the number of deaths, injured, sick, homeless, displaced, missing and other affected. Table 1 shows that this last variable represents 97% of the DH, caused mainly by soil and/or rock landslides (45.6% of the events). The data show that, regardless of the type of damage, the number of people impacted is high, generating high costs recurrently. In addition, Acciari and Ribeiro (2022) indicate that, in the year 2021 alone, the estimated investment for disaster prevention was R$ 2 million reais. However, in addition to not being spent, the amount was less than half of what was expected to be spent on Christmas decorations (R$ 5.5 million), indicating a disregard for the historical situation of the municipality.

Table 1 | Human Damage (HD) by typology of events present in the historical series of disaster occurrences in the municipality of Petrópolis, 2001 – 2022

COBRADE	11321	12200	13214	12100	12300	11311	TOTAL	
Total of human damages	373.959	95.623	348.561	1.119	40	15	819.317	100,00%
%	45.6	11.7	42.5	0.1	0.1	0.0	100.0	
Deaths	104	81	85	0	0	0	270	0.03%
Injured	530	16	356	0	0	0	902	0.11%
Sick	143	0	200	0	0	0	343	0.04%
Homeless	2287	2921	1629	0	0	0	6.837	0.83%
Displaced	6171	8605	660	19	8	15	15.478	1.89%
Missing [1]	23	0	203	0	0	0	226	0.03%
Other affected	364701	84000	345428	1100	32	0	795.261	97.06%

Source: The authors.

The historical average of DH shows an increase between 2001 and 2022. This average was exceeded in 2005, 2013 and 2022, with 2022 DH corresponding to 40.64% of the total for the period (Table 2), coinciding with the periods of higher precipitation. According to Cabral *et al*. (2023), the event that occurred in 2011 in the mountainous region of Rio (Petrópolis and Teresópolis) was the second-largest event in number of deaths caused by landslides in the history of Brazil.

Table 2 | Values of the annual distribution of Human Damage (HD) in Petrópolis

Year	2001	2003	2004	2005	2007	2008	2009	2010	2011	2013	2015	2016	2018	2022
Total of human damages	5773	1957	3847	130056	738	46906	22336	58544	48239	152292	0	0	15695	332934
%	0.70	0.24	0.47	15.87	0.09	5.73	2.73	7.15	5.89	18.59	0.00	0.00	1.92	40.64
Deaths	38	17	0	0	5	9	7	3	71	34	0	0	3	83
Injured	143	320	1	0	7	16	10	0	0	49	0	0	4	352
Sick	143	0	0	0	0	0	0	0	0	0	0	0	0	200
Homeless	812	88	89	0	223	81	29	7	2805	1074	0	0	0	1629
Displaced	4375	20	544	56	335	1800	90	33	6363	1135	0	0	260	467
Missing	22	0	0	0	0	0	0	1	0	0	0	0	0	203
Other affected	240	1512	3213	130000	168	45000	22200	58500	39000	150000	0	0	15428	330000

Source: The authors.

The monetary values of damage and losses (D&L) caused by flash floods in January 2011 represent 43% of the impact for Petrópolis in the period 2001 - 2022. In total, adding the percentages of other years (2001, 2008 and 2016), flash floods represent 52% of the D&L in the municipality and continue to reach very high figures (Table 3).

In this context, Cabral *et al*. (2023) state that the prospects for the municipality are not promising, considering the discontinuity of disaster prevention programs, such as the case of the alert program, which was not working during the 2022 rain.

Table 3 | Monetary values of damage and losses in Petrópolis: sum of material damage (MD), public losses (PL) and private losses (PRL)

YEAR	COBRADE	D&L US$	%
2001	11321	38,396,426.27	10
	12200	6,973,728.00	2
2003	11321	10,005,759.76	3
2004	11321	6,781,324.60	2
	12100	0.00	0
	12300	0.00	0
2005	11321	0.00	0
2007	11321	16,387,420.05	4
2008	12200	7,144,301.59	2
2009	11321	4,877,982.03	1
	12100	0.00	0
2010	11321	0.00	0
2011	12200	167,632,309.83	43%
2013	11311	6,211.18	0%
	11321	52,954,078.74	14%
2015	12200	4,216.85	0%
2016	12200	21,444,285.63	5%
	13214	2,052,260.06	1%
2018	12200	0.00	0%
	13214	2,234,802.67	1%
2022	13214	54,828,781.60	14%
2001 - 2022	**TOTAL US$**	**391,723,888.85**	**100%**

Source: The authors.

4 FINAL CONSIDERATIONS

With the analyses, it was possible to confirm that the event in 2022 was an extreme meteorological event, being the most severe of the last decades and associated with the highest human damage recorded in the municipality of Petrópolis. The study indicated that this event occurred, among other factors, due to rain concentrated in only one place, a point that needs further research.

The study did not find a significant change trend (positive or negative) for the monthly rainfall indices, RX1, RX5 or climatic anomalies for the municipality of Petrópolis. However, it is important to carry out additional studies to verify trends of extreme events, using time series of precipitation from other municipalities in the southeast region or considering other methodologies.

The analyses also identified that the event of 2022 was associated with the highest human damage recorded in Petrópolis. Regarding human damage, 2005 and 2013 can also be considered extreme since they greatly exceeded the annual average, all triggered by rainfall events.

Contrary to attributing the disaster only to the high rainfall volume, the study identified few indications of preventive actions that occurred prior to the rainy period or in the following months in favour of water drainage, reinforcing the need for improvement of governance related to disaster risk reduction in the short, medium and long term. However, this topic has not been deepened in the research in

question. In addition, there is evidence of discontinuity of disaster risk reduction programs in the municipality that require more attention.

NOTES

1| The number of missing people usually turns into the number of deaths.

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REFERENCES

ACCIARI, L.; RIBEIRO, M. **Risk, resilience and gender in the current Petrópolis tragedy**. UN Women, 2022. Available at: https://wrd.unwomen.org/explore/insights/risk-resilience-and-gender-current-petropolis-tragedy. Accessed on: 5 aug. 2023.

ALCÂNTARA, E. *et al*. **Deadly disasters in Southeastern South America**: flash floods and landslides of February 2022 in Petrópolis, Rio de Janeiro, Nat. Hazards Earth Syst. Sci. Discuss. Available at: https://doi.org/10.5194/nhess-2022-163, 2022.

ARAÚJO, L. M. N. *et al*. Avaliação da distribuição espaço-temporal histórica de eventos chuvosos no Rio de Janeiro. In: XIV WORLD WATER CONGRESS, 2011, Porto de Galinhas. **Proceedings** [...], 2010.

ASSUMPÇÃO, R. S. F. V. **Petrópolis – um histórico de desastres sem solução?** Do Plano Koeller ao Programa Cidades Resilientes. 2015. Tese (Doutorado em Ciências na área de Saúde Pública) – Escola Nacional de Saúde Pública Sérgio Arouca, Rio de Janeiro, 2015. Available at: https://www.arca.fiocruz.br/handle/icict/40233. Accessed on: 12 nov. 2022.

AVILA-DIAZ, A. *et al*. Assessing current and future trends of climate extremes across Brazil based on reanalyzes and earth system model projections. **Climate Dynamics**, v. 55, p. 1403–1426, 2020. Available at: https://doi.org/10.1007/s00382-020-05333-z.

BECK, Z. J. V. Meio ambiente e cidades resilientes: reflexões sobre o desastre em Petrópolis no ano de 2022. **Revista da Emerj**, v. 24, n. 2, p. 202–216. 2023.

BRASIL. Ministério do Desenvolvimento Regional. Secretaria de Proteção e Defesa Civil. Universidade Federal de Santa Catarina. Centro de Estudos e Pesquisas em Engenharia e Defesa Civil. **Atlas Digital de Desastres no Brasil**. Brasília: MDR, 2022. Available at: http://atlasdigital.mdr.gov.br/paginas/index.xhtml

BUNHAK, A. C. S.; WANDERLEY, H. S. Change in number of rainy days in the municipality of Visconde de Mauá, Rio de Janeiro. **Journal of Biotechnology and Biodiversity**, v. 8, n. 4. 2020. Available at: https://doi.org/10.20873/jbb.uft.cemaf.v8n4.bunhak

CABRAL, V. *et al*. The consequences of debris flows in Brazil: a historical analysis based on recorded events in the last 100 years. **Landslides**, v. 20, p. 511–529, 2023. Available at: https://doi.org/10.1007/s10346-022-01984-7

CAMARINHA, P. I.; DEBORTOLI, N. S.; HIROTA, M. **Índice de vulnerabilidade aos desastres naturais relacionados às secas no contexto de mudanças climáticas**. Produto II: Relatório com os resultados e discussões sobre o índice de vulnerabilidade e avaliação dos impactos relacionados às secas para as diferentes regiões do Brasil. Florianópolis: WWF Brasil. 2015.

CEMADEN; IBGE. **População em áreas de risco no Brasil**. 2018. Available at: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/21538-populacao-em-areas-de-risco-no-brasil.html?=&t=acesso-ao-produto. Accessed on: 15 nov. 2022.

COSTA, J. *et al*. Validação dos dados de precipitação estimados pelo Chirps para o Brasil. **Revista Brasileira de Climatologia**, v. 24, jan-jul. 2019. Available at: http://dx.doi.org/10.5380/abclima.v24i0.60237

COSTA, A. A. *et al*. Precipitation extremes over the tropical Americas under RCP4.5 and RCP8.5 climate change scenarios: results from dynamical downscaling simulations. **International Journal of Climatology**, p. 1–17. 2022. Available at: https://doi.org/10.1002/joc.7828.

COUTINHO, S. M. V. *et al*. The Nexus+ approach applied to studies of Impacts, vulnerability and adaptation to climate change in Brazil. **Sustainability in Debate**, [s. l.], v. 11, n. 3, p. 24–56, 2020. DOI 10.18472/SustDeb.v11n3.2020.33514.

DEBORTOLI, N. S. *et al*. An index of Brazil's vulnerability to expected increases in natural flash flooding and landslide disasters in the context of climate change. **Nat Hazards**, v. 86, p. 557–582. 2017. DOI 10.1007/s11069-016-2705-2.

DOURADO, F.; ARRAES, T. C.; SILVA, M. O Megadesastre da Região Serrana do Rio de Janeiro – as Causas do Evento, os Mecanismos dos Movimentos de Massa e a Distribuição Espacial dos Investimentos de Reconstrução no Pós-Desastre. **Anuário do Instituto de Geociências**, v. 35, n. 2, p. 43-54. 2012. Available at: http://dx.doi.org/10.11137/2012_2_43_54

FREITAS, M. A. S. Um sistema de suporte à decisão para o monitoramento de secas meteorológicas em regiões semiáridas. **Revista Tecnologia**, v. suplem, p. 84-95, 2005.

FUNK, C. *et al*. The climate hazards infrared precipitation with stations – a new environmental record for monitoring extremes. **Scientific data**, v. 2, n. 1, p. 1-21, 2015. Available at: https://doi.org/10.1038/sdata.2015.66

GRUBERTT, B. **Seis meses após tragédia em Petrópolis, famílias retornam para áreas de risco e obras de contenção ainda não foram realizadas**. G1, 15 ago. 2022. Bom Dia Rio. Available at: https://g1.globo.com/rj/rio-de-janeiro/noticia/2022/08/15/seis-meses-apos-tragedia-em-petropolis-familias-retornam-para-areas-de-risco.ghtml. Accessed on: 13 nov. 2022.

IBGE. Conselho Nacional de Estatística, Serviço Nacional de Recenseamento. **Censo Demográfico de 1940**. Available at: https://biblioteca.ibge.gov.br/visualizacao/periodicos/65/cd_1940_p15_rj.pdf. Accessed on: 18 nov. 2022.

IBGE. **População em áreas de risco no Brasil**. Rio de Janeiro: IBGE. 2018. 91 p.

IBGE. **Censo Demográfico 2010**. Rio de Janeiro, 2010. Available at: https://censo2010.ibge.gov.br/resultados.html. Accessed on: 14 nov. 2022.

IBGE. B**iomas e Sistema Costeiro Marinho do Brasil compatível com a escala 1:250.000**. Série Relatórios Metodológicos. 2019. Available at: https://www.ibge.gov.br/apps/biomas/#/home. Accessed on: 4 nov. 2022.

IBGE. **Cidades**. Available at: http://cidades.ibge.gov.br/. Accessed on: 8 nov. 2022.

IPCC. **Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation**. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [FIELD, C. B. *et al*. (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 2012. 582 p.

IPCC. **Climate Change 2021**: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V. *et al*. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 3−32. 2022. DOI 10.1017/9781009157896.001.

IPCC. **Climate Change 2022**: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [PÖRTNER, H.-O. *et al*. (eds.)]. Cambridge University Press. In Press. 2022. DOI 10.1017/9781009325844

KENDALL, M. G. **Rank Correlation Measures**. Ed. Charles Griffin. London. Lira, C. S. 1975.

LAHSEN, M.; RIBOT, J. Politics of attributing extreme events and disasters to climate change. **Wires Climate change**, v. 13. 2022. DOI 10.1002/wcc.750

MANN, H. B. Nonparametric tests against trend. **Econometrica: Journal of the econometric society**, p. 245-259. 1945.

MAPBIOMAS. **Mapeamento anual das áreas urbanizadas no Brasil entre 1985 e 2020**. 2021. Available at: https://drive.google.com/file/d/1cZ7KoUywnDcLAkokanjxoYmNAPffsVBW/view?usp=sharing. Accessed on: 28 nov. 2022.

MORAES, O. L. L. Proposing a metric to evaluate early warning system applicable to hydrometeorological disasters in Brazil. **International Journal of Disaster Risk Reduction**, v. 87, 13p. 2023. Available at: https://doi.org/10.1016/j.ijdrr.2023.103579

OSCAR JÚNIOR, A. C. Precipitation Trends and Variability in River Basins in Urban Expansion Areas. **Water Resour Manage**, v. 35, p. 661–674, 2021. Available at: https://doi.org/10.1007/s11269-020-02749-4

PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS. **Base científica das mudanças climáticas**. Contribuição do Grupo de Trabalho 1 do Painel Brasileiro de Mudanças Climáticas ao Primeiro Relatório da Avaliação Nacional sobre Mudanças Climáticas [AMBRIZZI, T.; ARAÚJO, M. (eds.)]. COPPE. Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil, 464 p. 2-14. 2014.

PRABHAKAR, S. V. R. K.; SRINIVASAN, A.; SHAW, R. Climate change and local level disaster risk reduction planning: need, opportunities and challenges. **Mitig Adapt Strateg Glob Change**, v. 14, p. 7–33. 2009.

PREFEITURA MUNICIPAL DE PETRÓPOLIS. **Plano Municipal de Redução de Risco (PMRR)**: 1ª (Revisão), 2º, 3º, 4º e 5º Distritos – Petrópolis, RJ - Programa de Urbanização, Regularização e Integração de Assentamentos Precários – 6a Etapa Reflexão e Proposição de Estratégias de Intervenções não estruturais para a Redução do Risco. Petrópolis: Prefeitura Municipal de Petrópolis (PMP) – Secretaria de Habitação (SEH), 2017. Available at: https://sig.petropolis.rj.gov.br/cpge/Reflexoes.pdf. Accessed on: 30 oct. 2022.

ROOY, M. P. V. A rainfall anomaly index independent of time and space. Notes. **Weather Bureau of South Africa**, v. 14, p. 43-48, 1965.

ROZANTE, J. R. *et al*. Combining TRMM and Surface Observations of Precipitation: technique and validation over South America. **Weather and Forecasting**, v. 25, p. 885-894, 2010.

SERVIÇO GEOLÓGICO DO ESTADO DO RIO DE JANEIRO. **Cartografia Geotécnica de Aptidão Urbana, 1:10.000 de Petrópolis a "CGU do DRM"** – junho/2015 – Relatório Técnico. 73 p. 2015.

SILVA, S. V. C. da. *et al*. Modelagem bayesiana da precipitação máxima de Petrópolis (RJ) e Poços de Caldas (MG). **Engenharia Sanitária e Ambiental**, v. 28, 2023. Available at: https://doi.org/10.1590/S1413-415220210342

SILVA, F. P. *et al*. Identification of rainfall and atmospheric patterns associated with Quitandinha River flooding events in Petrópolis, Rio de Janeiro (Brazil). **Nat Hazards**, v. 103, p. 3745–3764, 2020. Available at: https://doi.org/10.1007/s11069-020-04153-y

STOTT, P. A. *et al*. Attribution of extreme weather and climate-related events. **Wiley Interdisciplinary Reviews**: climate change, [s. l.], v. 7, n. 1, p. 23–41, 2016. DOI 10.1002/wcc.380.

TORRES, G. P.; CARMO, L. F. R.; PALMEIRA, A. C. P. Estudo da relação entre precipitação e deslizamentos no município de Petrópolis-RJ. **Revista S&G**, n. 15, 2020.

VILLARINI, G. *et al*. Examining flood frequency distributions in the midwest U.S. **Journal of the American Water Resources Association**, v. 47, n. 3, p. 447-463, 2011. Available at: https://doi.org/10.1111/j.1752-1688.2011.00540.x

Identificação de eventos extremos de precipitação e desastres deflagrados por chuvas no município de Petrópolis-RJ

Identification of extreme rainfall events and disasters triggered by rain in the city of Petrópolis-RJ

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ARTICLE- VARIA

RESUMO

O município de Petrópolis-RJ, Brasil, está exposto a eventos extremos de precipitação, que resultam em danos e perdas econômicas diretas e indiretas. Para verificar o aumento ou não desses eventos, o objetivo foi avaliar o padrão temporal das chuvas no município (1976-2022), identificando se o evento ocorrido em 2022 pode ser considerado um evento extremo, bem como a relação entre pluviometria e intensidade do impacto, em termos dos danos e perdas deflagrados. Foram então calculados os acumulados de precipitação em 24 horas (RX1), em 5 dias (RX5), percentis 95 e 99 (R95 e R99), Índice de Anomalia de Chuvas (IAC) e análises de tendência pelo método Mann-Kendall, bem como dados

de perdas e danos. Os resultados não indicaram viés de aumento dos extremos de precipitação, embora tenha confirmado o evento ocorrido em fevereiro de 2022 como um evento extremo, o qual se configurou como o maior da série histórica analisada.

Palavras-chave: Extremos de precipitação. Petrópolis-RJ. Desastres relacionados à chuva. Ocorrência de desastres.

ABSTRACT

The municipality of Petrópolis-RJ, Brazil, is prone to extreme rainfall events that cause damage and direct and indirect economic losses. In order to verify the increase or not of these events, this study evaluates the temporal pattern of rainfall in the municipality (1976-2022), identifying whether the event that occurred in 2022 can be considered an extreme event, as well as the relationship between rainfall and impact intensity, in terms of damage and losses triggered. The accumulated rainfall over 24 hours (RX1), over 5 days (RX5), the 95th and 99th percentiles (R95 and R99), the Rainfall Anomaly Index (RAI) and trend analyses using the Mann-Kendall method, as well as loss and damage data were then calculated. The results did not indicate a trend towards an increase in precipitation extremes, although they did confirm the February 2022 event as an extreme event, which stood out as the largest within the historical series analysed.

Keywords: Precipitation extremes. Petrópolis-RJ. Rain-related disasters. Occurrence of disasters.

1 INTRODUÇÃO

Desde a década de 1990, são publicados relatórios do Painel Intergovernamental sobre Mudanças Climáticas (IPCC) acerca das alterações e expectativas relacionadas ao clima no planeta, entre elas mudanças significativas na magnitude e frequência de fenômenos meteorológicos extremos (IPCC, 2012, 2021). O último relatório indica também que houve aumento do impacto nos ecossistemas, pessoas e assentamentos em função das mudanças climáticas induzidas pelo homem (IPCC, 2022).

Para compreender os danos associados a eventos extremos meteorológicos, primeiro é necessário reconhecer esses eventos. A Organização Meteorológica Mundial (WMO) os define como eventos meteorológicos que se desviam significativamente das condições médias, levando em consideração uma série histórica de, no mínimo, 20 anos, e o potencial de causar perigos ou impactos significativos nas atividades humanas e no meio ambiente (IPCC, 2022).

Em função das vulnerabilidades presentes no território e da predisposição dos elementos expostos a sofrer perdas e danos, os eventos meteorológicos extremos podem deflagrar desastres de maior ou menor severidade (COUTINHO *et al*., 2020; DEBORTOLI *et al*., 2017; IPCC, 2012; LAHSEN; RIBOT, 2020).

Nas regiões tropicais, existem evidências de que esteja ocorrendo um aumento da frequência e intensidade das chuvas extremas, com o desdobramento de diversos impactos gerados por elas, que são potencializados pela baixa capacidade de adaptação dos países em desenvolvimento (PRABHAKAR *et al*., 2009).

No Brasil grande parte das ocorrências de desastres é causada por fenômenos deflagrados por chuvas, por exemplo, enxurradas, inundações e movimentos de massa úmida (PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS, 2014). Se considerarmos o aumento dos valores médios da temperatura do ar decorrente das mudanças climáticas – cenário previsto para diversas regiões do país –, aumenta a expectativa de que ocorram cada vez mais eventos de chuva extrema e, com isso, também aumenta a probabilidade de ocorrência de desastres. Para verificar essa hipótese e desenvolver estratégias de adaptação para o país, é fundamental monitorar a ocorrência de eventos extremos no território.

A região serrana do estado do Rio de Janeiro é um exemplo de cidade com efeito cascata gerado por precipitações intensas. Em janeiro de 2011, ocorreu um desastre que ocasionou danos e perdas em pelo menos sete municípios, incluindo o município de Petrópolis, vitimando aproximadamente 947 pessoas (DOURADO *et al*., 2012).

Petrópolis é afetada recorrentemente por chuvas intensas, e possui registros de desastres datados de 1950 (ASSUMPÇÃO, 2015). Mais recentemente, entre janeiro e março de 2022, ocorreram três episódios de chuvas intensas associados a Tempestade Local Convectiva que deflagraram impactos severos sobre a população. O mais grave foi em 15 de fevereiro, que resultou na morte de ao menos 234 pessoas (ALCÂNTARA *et al*., 2022; GRUBERTT, 2022).

Diante dessas cifras assustadoras, surgem questionamentos acerca do que poderia ser feito para reduzir o risco de desastres provocados por chuvas nessa região e, considerando que o conhecimento do risco é um dos quatro pilares fundamentais para a redução do risco de desastres, o objetivo deste trabalho foi analisar o padrão temporal dos eventos extremos de chuvas (Ameaça), identificando se, de fato, o evento ocorrido em 2022 pode ser considerado um evento extremo, bem como a relação entre pluviometria e intensidade do impacto, em termos dos danos e perdas deflagrados no município.

2 MATERIAIS E MÉTODOS

2.1 ÁREA DE ESTUDO

O município de Petrópolis está localizado nas coordenadas 22°30'17" de latitude Sul e 43°10'42" de longitude Oeste, na região serrana do estado do Rio de Janeiro. Segundo o Serviço Geológico do Estado do Rio de Janeiro, na Carta Geotécnica de Aptidão Urbana, a somatória de áreas com moderada e alta susceptibilidade a movimentos de massa corresponde a 64,06% do município.

De acordo com dados de 2022, há em Petrópolis uma população estimada de 278.881 habitantes; e densidade demográfica de 352,50 hab./km² (IBGE, 2022). O município apresentou um crescimento de quatro vezes em 80 anos, passando de 75,4 mil habitantes, em 1940, para 278.881 habitantes, em 2022 (IBGE, 1940, 2022).

A população de Petrópolis do Censo de 2010 (último disponível à data desta publicação) era de 295.917 pessoas, das quais 72.070 (isto é, 24,35%) residiam em áreas de risco, distribuídas em 22.298 domicílios (CEMADEN; IBGE, 2018). Apesar disso, o município contava com um Índice de Desenvolvimento Humano Municipal (IDHM) de 0,745 (IBGE, 2010), o qual é considerado alto e dentro da média para o Brasil cujo IDH nacional estava em 0,727. Segundo a prefeitura de Petrópolis, hoje, e apesar dos eventos adversos enfrentados nesse município na última década, esse índice cresceu, chegando a 0,804, enquanto o do Brasil baixou para 0,724.

2.2 DADOS

Os dados pluviométricos utilizados neste trabalho provêm da estação de medição automática Xerém, pertencente à rede Inmet, localizada em Duque de Caxias (-43° 30' 14.004" S, 22° 55' 33.996" W). Essa estação é a mais próxima da área de estudo (aproximadamente 15 km) e conta com a maior série histórica. De forma complementar, também foram utilizados dados de precipitação da estação São Sebastião, pertencente à rede do Centro Nacional de Monitoramento e Alertas de Desastres Naturais (Cemaden), localizada no município de Petrópolis.

O período de análise deste estudo foi estabelecido entre 1976 e 2022, devido à disponibilidade da maior quantidade de dados nesse intervalo. Embora seja um período longo, é importante ressaltar que os dados das estações meteorológicas apresentam algumas falhas, as quais foram corrigidas por meio da utilização de valores médios de chuva interpolados a partir dos dados do Climate Hazards Group InfraRed Precipitation with Station data – Chirps (FUNK *et al*., 2015) e do Produto Merge do Centro de Previsão de Tempo e Estudos Climáticos (ROZANTE *et al*., 2010). Esses conjuntos de dados de chuva possuem uma resolução espacial aproximada de 5 km e 10 km, respectivamente.

Metodologia similar foi desenvolvida por Costa *et al*. (2019), que se propôs validar dados de precipitação no Brasil utilizando dados do Chirps. Costa identificou compatibilidade de 95,4% entre os dados do Inmet e os do Chirps, o qual legitima o uso desses dados para completar as falhas da série histórica selecionada para este estudo. Assim, a partir de dados de precipitação das estações meteorológicas de Xerém e de São Sebastião e complementados pelos dados do Chirps e Merge, foi construída uma série temporal de dados diários de precipitação do período de 1976 a 2022.

2.3 METODOLOGIA

2.3.1 ÍNDICES CLIMÁTICOS

Os índices calculados para auxiliar na compreensão do padrão temporal da precipitação no município de Petrópolis e identificar os valores extremos foram:

- Pt - Precipitação total anual
- Pmed - Precipitação média anual
- Ptri - Somatório da média móvel trimestral
- R95 - Número de dias em que a precipitação diária foi maior do que 95% das precipitações do período
- R99 - Número de dias em que a precipitação diária foi maior do que 99% das precipitações do período
- RX1 - Máximo valor anual em um dia de precipitação
- RX5 - Máximo valor de precipitação em cinco dias consecutivos

2.3.2 ÍNDICE DE ANOMALIA DE CHUVAS

Além dos índices apresentados, também foi calculado o Índice de Anomalia de Chuvas (IAC), que considera a média das dez maiores chuvas ocorridas dentro do período de análise, bem como a média das dez menores, sendo as anomalias positivas aquelas acima da média e as anomalias negativas aquelas abaixo da média. O IAC é classificado em termos de períodos secos e úmidos, como proposto por Rooy (1965) e adaptado por Freitas (2005). As anomalias podem ser expressas da seguinte forma:

Anomalias positivas

$$IAC = 3\left[\frac{(N - \underline{N})}{(\underline{M} - \underline{N})}\right]$$

Anomalias negativas

$$IAC = -3\left[\frac{(N - \underline{N})}{(\underline{X} - \underline{N})}\right]$$

Em que N é a precipitação mensal, _N é a média da série, _M é a média das dez maiores precipitações e _X é a média das dez menores precipitações. Ainda de acordo com o índice, a classificação da pluviosidade varia de extremamente chuvoso a extremamente seco.

2.3.3 TESTE DE MANN-KENDALL

O teste de Mann-Kendall (KENDALL, 1975; MANN, 1945) é um teste não paramétrico sugerido pela Organização Meteorológica Mundial (OMM) para verificar se as séries apresentam tendências temporais estatisticamente significativa, e tem sido utilizado com bastante eficiência. Assim, para que a tendência seja confirmada, o valor p-valor precisa ser inferior a 0,05%, representando uma confiança de 95%.

Assim, o teste foi aplicado visando identificar possíveis tendências no padrão temporal da precipitação anual e nos índices RX1, RX5 e IAC.

2.3.4 METODOLOGIAS UTILIZADAS PARA CÁLCULOS DE PERDAS E DANOS

Após a análise da ameaça de eventos extremos de chuvas, foram realizadas análises dos danos e perdas causados por desastres relacionados à chuva no município de Petrópolis. Essas análises foram baseadas em dados provenientes do Sistema Integrado de Informações sobre Desastres (S2iD), o qual incorpora diversos produtos da Secretaria Nacional de Proteção e Defesa Civil – Sedec (BRASIL, 2022). A série histórica utilizada corresponde ao período de dados disponível para Petrópolis, isto é, 2001 – 2022. As tipologias utilizadas na classificação de desastres nesta base de dados seguem a Codificação Brasileira de Desastres – Cobrade.

No S2iD os dados sobre impacto estão agrupados em quatro categorias: danos humanos (DH), danos materiais (DM), prejuízos públicos (PEPL) e prejuízos privados (PEPR), as mesmas utilizadas na presente análise. Os valores referentes a DM, PEPL e PEPR receberam correção monetária com referência a dezembro de 2022 e foram sintetizados em uma única variável que representa o total de danos e perdas (D&L: *damage and losses* em inglês), transformados a dólares americanos.

Um resumo das etapas metodológicas desenvolvidas pode ser observado na Figura 1.

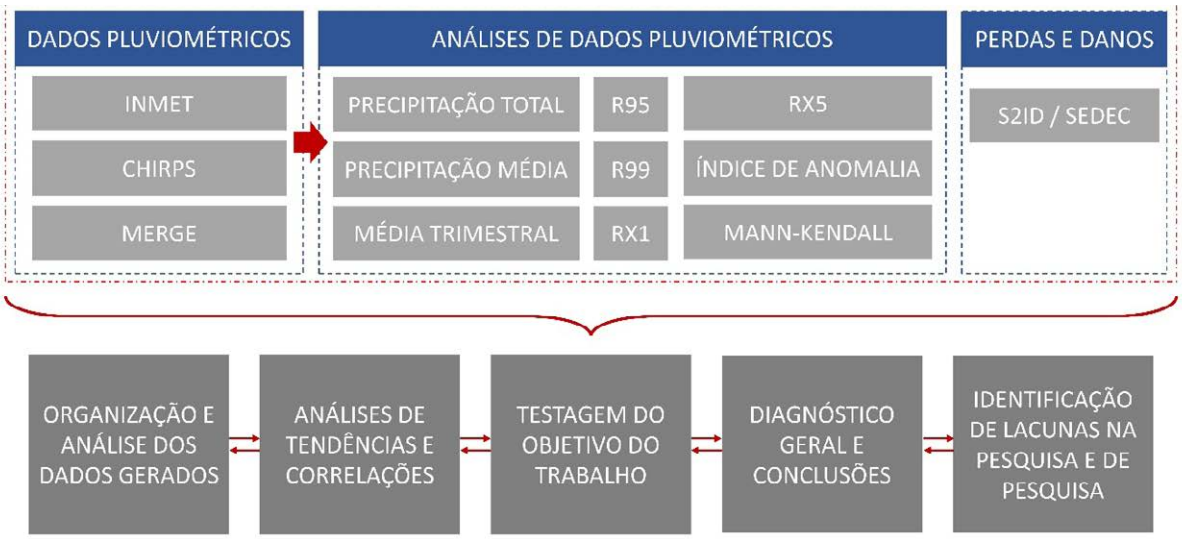

Figura 1 | Infográfico com as etapas metodológicas

Fonte: Elaboração própria.

3 RESULTADOS E DISCUSSÃO

3.1 ANÁLISE DO PADRÃO TEMPORAL DOS EVENTOS EXTREMOS DE CHUVAS

No período de 1976 a 2022, a chuva média mensal se manteve mais ou menos constante em torno da média mensal multianual (Figura 2), numa faixa de desvio padrão de 77 mm, com exceção dos anos de 1999, com um extremo negativo de 5,5 mm (uma vez menor do que a média), e de 2022, com um extremo positivo de 358,6 (três vezes a média).

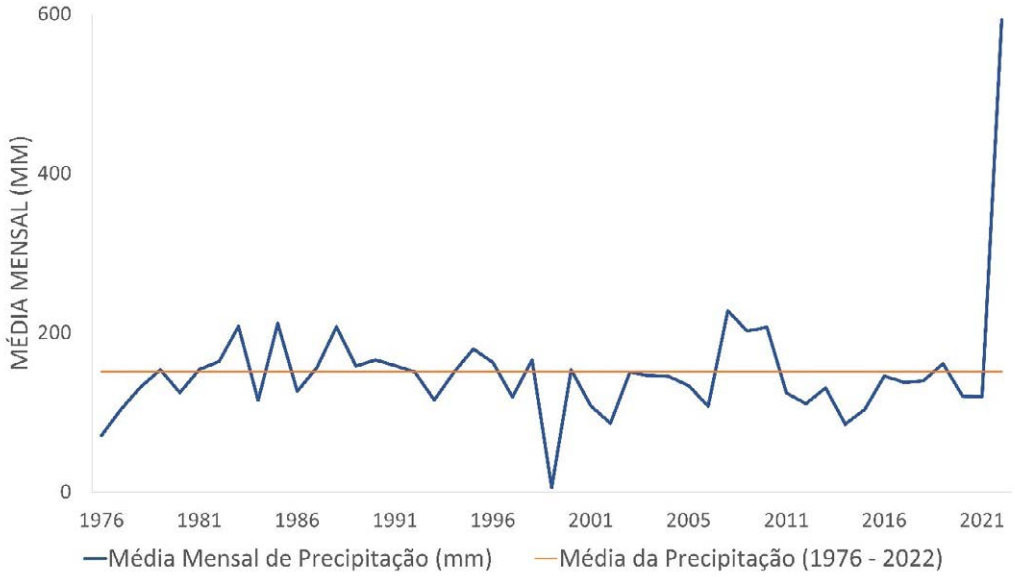

Figura 2 | Acumulado médio mensal e média mensal multianual de precipitação em Petrópolis

Fonte: Elaboração própria.

Os resultados do teste de Mann-Kendall indicaram uma tendência de redução no volume de chuvas ao longo do período, porém não apresentou significância estatística. Esse resultado corrobora a análise realizada por Silva *et al*. (2023) que, ao analisarem a tendência climática de Petrópolis, não encontraram a presença de tendência pelos testes de Ljung-Box e Mann-Kendall, e diverge das análises de Oscar-Júnior (2021) que indica que existe uma tendência estatisticamente significativa de aumento de pluviometria mensal em Petrópolis, embora os autores tenham utilizado diferentes séries temporais.

A concentração de chuva em determinados períodos do ano também foi avaliada para a série. A análise de médias móveis de precipitação trimestral indicou que o trimestre novembro – dezembro – janeiro teve a maior média mensal de chuvas, seguido pelo trimestre dezembro – janeiro – fevereiro, antecedendo a estação chuvosa. Foi nessa estação que ocorreram os dois eventos com maior número de vítimas: 11 de janeiro de 2011 e 15 de fevereiro de 2022. De acordo com Silva *et al*. (2020), o acúmulo de chuvas entre os meses de outubro e março ocorre em função do sistema meteorológico Zona de Convergência do Atlântico Sul, que atua fortemente na região, gerando tempestades locais.

Embora não sejam conclusivos acerca da motivação dos eventos, esses resultados indicam que as ações de prevenção e preparação da resposta a eventuais eventos extremos de precipitação devem anteceder o início da estação chuvosa na região, além de necessitarem de maior foco em ações de médio e longo prazo. Beck (2023) aponta que já existem ações nesse sentido em desenvolvimento no município, como um estudo para a criação de barreiras para contenção de movimentos de massa e o Plano Municipal de Redução de Risco, ambos como parte de um plano para tornar a cidade mais resiliente.

Embora os eventos extremos tenham características únicas, eles podem fazer parte de eventos regionais ou ainda ser desencadeados em função de características específicas do local, assim, é preciso ter um diagnóstico consolidado da área que permita a realização de ações efetivas em prol da resiliência, e que envolvam não apenas análises pluviométricas. Nesse sentido, Alcântara *et al*. (2023) indicam que outros fatores, como a remoção de vegetação nativa, o crescimento populacional em áreas com declividade entre 45o-60º e a falta de planejamento urbano são fatores que contribuem significativamente para a ocorrência de desastres no município.

Ainda com relação à análise dos dados de precipitação, os extremos de chuvas também foram avaliados por meio do índice RX1, que retorna os valores máximos de precipitação em 24 horas para cada ano (Figura 3). O maior volume de chuva de toda a série temporal ocorreu no dia 21 de março de 2022, com um total de 358,6 mm, seguido pelo dia 12 de fevereiro de 1998, com um total de 301,4 mm. O teste de Mann-Kendall não apresentou tendência significativa de alteração no valor máximo de chuva..

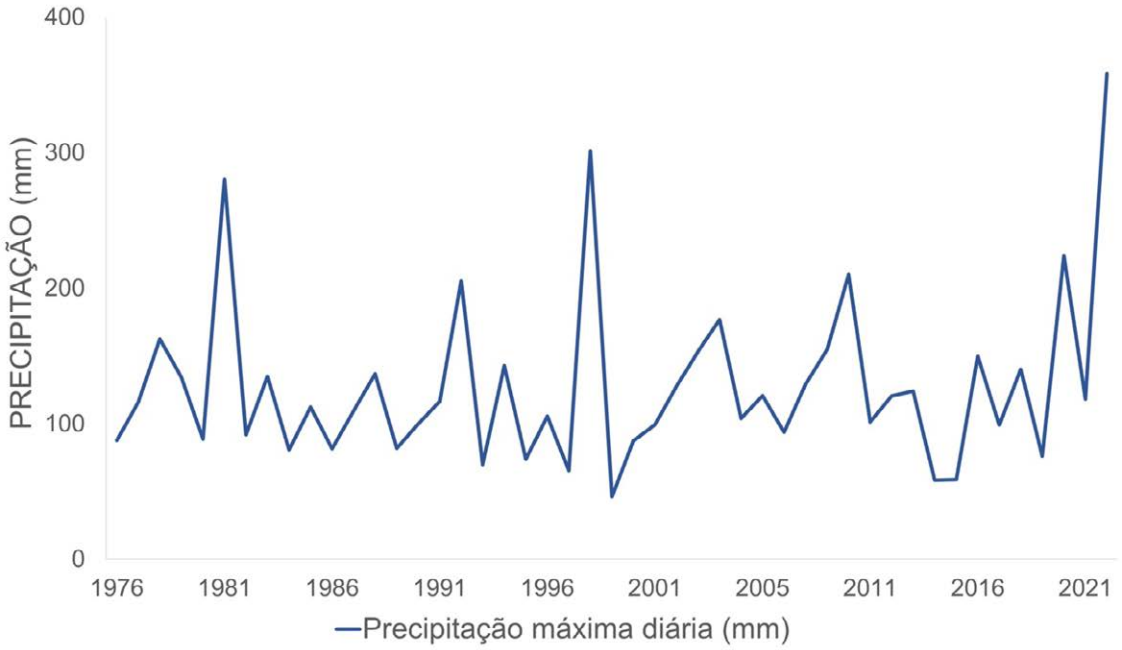

Figura 3 | Evolução temporal do índice RX1 para o município de Petrópolis

Fonte: Elaboração própria.

Cabe ressaltar que, em relação aos dados diários, o pluviômetro instalado pelo Cemaden no bairro São Sebastião, principal bairro afetado pelas chuvas de 2022, registrou 260 mm de precipitação acumulados em duas horas e meia em 15 de fevereiro de 2022, e 476,8 mm acumulados em 24 horas entre os dias 20 e 21 de março, já o pluviômetro do bairro Quitandinha, a cerca de 3 km de distância, marcou 200 mm, indicando que o evento pode ter sido extremamente concentrado. Infelizmente, em função do reduzido número de pluviômetros no município, incluindo uma série histórica dos eventos, não é possível confirmar se essa concentração de fato existiu ou ainda se é recorrente, como indicam os dados. Apesar disso, seguindo nessa linha, Oscar-Júnior (2021) indicou uma tendência de redução do número de dias chuvosos com um aumento da concentração das chuvas em eventos diários ou de até cinco dias consecutivos para o município.

Com relação ao volume máximo de chuva acumulado em cinco dias (RX5), não foi possível constatar tendência de aumento do número de dias chuvosos pelo teste de Mann-Kendall. Ao analisar o percentil 95 da série histórica, observam-se em média 17 dias de chuva por ano acima da média da série (Figura 4).

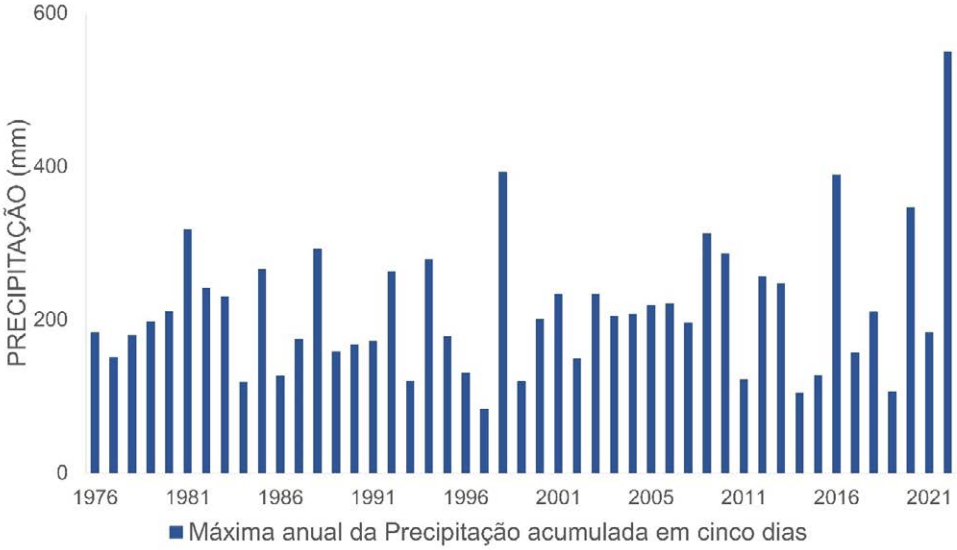

Figura 4 | Distribuição temporal (anual) do índice RX5 no município de Petrópolis

Fonte: Elaboração própria.

O percentil 95 para os valores máximos de acumulados de chuva em cinco dias (RX5) apresenta o valor de 376,1 mm, e o percentil 99 mostra 477,07 mm, ambos abaixo do valor de chuva acumulado em cinco dias em 2022, o qual em apenas um dia a precipitação foi de 358,6 mm. Esse resultado confirma a excepcionalidade do evento ocorrido em fevereiro de 2022, o que possibilita seu enquadramento como um evento extremo.

Ainda visando a compreensão da dinâmica da distribuição pluviométrica, o Índice de Anomalia de Chuvas (IAC) calculado apontou 26 anos extremamente chuvosos, muito chuvosos ou chuvosos, assim como 26 anos secos e dois muito secos (Figura 5), embora não tenha sido possível correlacionar se os anos com maiores anomalias positivas resultaram em um maior número de vítimas ou ainda qualquer tendência (pelo teste de Mann-Kendall) de que o número de anomalias positivas ou negativas esteja aumentando, foi possível observar que o ano de 2022 teve a maior anomalia positiva do período, confirmando ainda mais a excepcionalidade do evento.

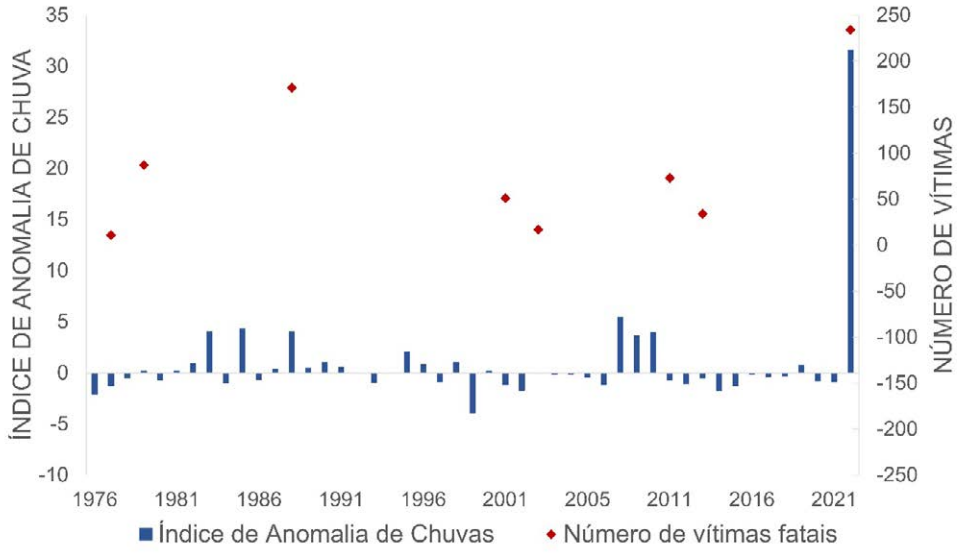

Figura 5 | Índice de Anomalia Climática (IAC) e anos com vítimas fatais no município de Petrópolis

Fonte: Elaboração própria.

A ocorrência de anomalias pode estar associada à presença de outros eventos meteorológicos, como a Zona de Convergência do Atlântico Sul (ZCAS) ou ainda Sistemas Frontais, que potencializam a pluviometria, ocasionando a cheia de rios, facilitando a ocorrência de deslizamentos e movimentos de massa e, consequentemente, a perda de vidas (SILVA *et al*., 2020), eventos recorrentes no município de Petrópolis. No caso específico do evento ocorrido em 2022, Alcântara *et al*. (2023) indicam que a ZCAS estava posicionada sobre o estado do Rio de Janeiro, favorecendo a convecção atmosférica e consequente instabilidade meteorológica.

Os dados apresentados ao longo do trabalho corroboram estudos que indicam que essa região tem passado por uma alteração no cenário climático que, embora não afete significativamente a quantidade de chuva total anual, altera a distribuição, levando a um aumento da probabilidade de ocorrência de eventos extremos de precipitação, mais especificamente aumento dos casos de grandes volumes de chuva em um tempo muito curto (OSCAR JÚNIOR, 2021; SILVA *et al*., 2020; SILVA *et al*., 2023).

Com a presente análise não foi possível correlacionar se o acumulado de chuvas teve influência no número de vítimas fatais, levando em consideração que a suscetibilidade é a somatória de diversos parâmetros e que Petrópolis apresenta um cenário de multiperigos, embora seja possível afirmar que as mortes ocorreram em decorrência dos eventos pluviométricos. Para realizar essa correlação, seria necessário aprofundar as análises e incluir outros fatores, como declividade e uso e ocupação do solo. Nesse sentido, Alcântara *et al*. (2023) afirmam que as taxas e a forma como a urbanização ocorreu em Petrópolis superam as características climáticas como indutores de deslizamentos e, consequentemente, desastres, uma vez que a maior parte das construções está localizada em áreas com declividade superior a 20%.

A urbanização afeta e é afetada diretamente pela concentração do volume de chuvas, influindo na definição de locais propícios à moradia, por exemplo. Por consequência, gera preocupação em relação à capacidade do município em responder à alta concentração de chuva em um curto período.

Embora a Prefeitura Municipal de Petrópolis tenha implementado ações como o Sistema de Alerta e Alarme, de acordo com o Plano Municipal de Redução de Risco, não foram realizadas intervenções físicas no sentido de melhorar o escoamento de água durante os eventos chuvosos (PREFEITURA MUNICIPAL DE PETRÓPOLIS, 2017), o que potencializa o efeito negativo das chuvas.

3.2 ANÁLISE DE DANOS E PERDAS ASSOCIADOS À CHUVA

Com base na série histórica de ocorrência de desastres referentes ao município de Petrópolis, período 2001 – 2022, observa-se que as tipologias de ameaças com maior número de ocorrências são deslizamentos de solo/ou rocha, enxurradas e chuvas intensas. A distribuição desses eventos ocorreu entre os meses de outubro (início da estação chuvosa) e abril (fim da estação chuvosa), coincidindo com os meses que retornaram maiores índices pluviométricos na análise (Figura 6). Os dados corroboram um estudo realizado por Torres *et al*. (2020), que indica que o número de deslizamentos tem apresentado uma tendência crescente no município de Petrópolis, estando diretamente relacionados com altos valores de precipitação, principalmente quando os acumulados passam de 48h ou 72h.

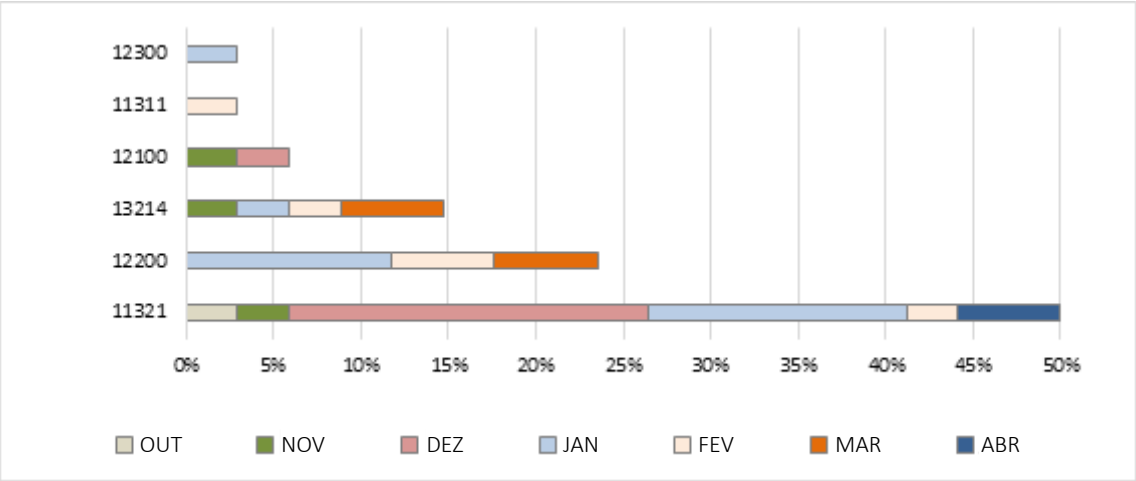

Figura 6 | Distribuição mensal de desastres por tipologia de ameaças em Petrópolis. 12300 Alagamento (1); 11311 Queda de blocos (1); 12100 Inundação (2); 13214 Chuvas Intensas (5); 12200 Enxurrada (8); 11321 Deslizamento de solo e/ou rocha (17).

Fonte: Elaboração própria.

Os danos humanos (DH) referem-se ao impacto sobre pessoas; na base de dados trata-se do número de óbitos, feridos, enfermos, desabrigados, desalojados, desaparecidos e outros afetados. Na Tabela 1 observa-se que esta última variável representa 97% dos DH, causados principalmente por deslizamentos de solo e/ou rocha (45,6% dos eventos). Os dados evidenciam que, independente do tipo de dano, o número de pessoas impactadas é alto, gerando gastos elevados recorrentemente. Além disso, Acciari e Ribeiro (2022) indicam que, apenas no ano de 2021, a estimativa de investimentos para prevenção de desastres era de R$ 2 milhões, no entanto, além de não ter sido gasto, o valor era menor do que a metade prevista para ser gasta com decorações natalinas (R$ 5,5 milhões), indicando um descaso com a situação histórica do município.

Tabela 1 | Danos humanos (DH) por tipologia de eventos presentes na série histórica de ocorrências de desastres no município de Petrópolis, período 2001 – 2022

COBRADE	*11321*	*12200*	*13214*	*12100*	*12300*	*11311*	*TOTAIS*	
Total danos humanos	373.959	95.623	348.561	1.119	40	15	819.317	100,00%
%	45.6	11.7	42.5	0.1	0.1	0.0	100.0	
Óbitos	104	81	85	0	0	0	270	0.03%
Feridos	530	16	356	0	0	0	902	0.11%
Enfermos	143	0	200	0	0	0	343	0.04%
Desabrigados	2287	2921	1629	0	0	0	6.837	0.83%
Desalojados	6171	8605	660	19	8	15	15.478	1.89%
Desaparecidos[1]	23	0	203	0	0	0	226	0.03%
Outros afetados	364701	84000	345428	1100	32	0	795.261	97.06%

Fonte: Elaboração própria.

A média histórica de DH apresenta uma crescente entre 2001 e 2022. Essa média foi excedida em 2005, 2013 e 2022, sendo que em 2022 os DH correspondem a 40,64% do total do período (Tabela 2), coincidindo, novamente, com os períodos de maior precipitação. Segundo Cabral *et al*. (2023), o evento ocorrido em 2011 na região serrana do Rio (Petrópolis e Teresópolis) foi o segundo maior evento em número de mortes ocorrido em função de deslizamentos na história do Brasil.

Tabela 2 | Valores da distribuição anual dos danos humanos (DH) em Petrópolis

Ano	*2001*	*2003*	*2004*	*2005*	*2007*	*2008*	*2009*	*2010*	*2011*	*2013*	*2015*	*2016*	*2018*	*2022*
Total danos humanos	5773	1957	3847	130056	738	46906	22336	58544	48239	152292	0	0	15695	332934
%	0.70	0.24	0.47	15.87	0.09	5.73	2.73	7.15	5.89	18.59	0.00	0.00	1.92	40.64
Óbitos	38	17	0	0	5	9	7	3	71	34	0	0	3	83
Feridos	143	320	1	0	7	16	10	0	0	49	0	0	4	352
Enfermos	143	0	0	0	0	0	0	0	0	0	0	0	0	200
Desabrigados	812	88	89	0	223	81	29	7	2805	1074	0	0	0	1629
Desalojados	4375	20	544	56	335	1800	90	33	6363	1135	0	0	260	467
Desaparecidos	22	0	0	0	0	0	0	1	0	0	0	0	0	203
Outros afetados	240	1512	3213	130000	168	45000	22200	58500	39000	150000	0	0	15428	330000

Fonte: Elaboração própria.

Os valores monetários de danos e perdas (D&L) causados por enxurradas em janeiro de 2011 representam 43% do impacto para Petrópolis no período 2001 – 2022. No total, somando as percentagens de outros anos (2001, 2008 e 2016), as enxurradas representam 52% dos D&L no município, e seguem atingindo cifras altíssimas (Tabela 3). Nesse contexto, Cabral *et al*. (2023) afirmam que as perspectivas do município não são promissoras, tendo em vista a descontinuidade dos programas de prevenção de desastres, como o caso do programa de alerta, que não estava funcionando durante a chuva de 2022.

Tabela 3 | Valores monetários de danos e perdas em Petrópolis: soma de danos materiais (DM), prejuízos públicos (PEPL) e prejuízos privados (PEPR)

ANO	*COBRADE*	*D&L US$*	*%*
2001	11321	38,396,426.27	10
	12200	6,973,728.00	2
2003	11321	10,005,759.76	3
2004	11321	6,781,324.60	2
	12100	0.00	0
	12300	0.00	0
2005	11321	0.00	0
2007	11321	16,387,420.05	4
2008	12200	7,144,301.59	2
2009	11321	4,877,982.03	1
	12100	0.00	0
2010	11321	0.00	0
2011	12200	167,632,309.83	43%
2013	11311	6,211.18	0%
	11321	52,954,078.74	14%
2015	12200	4,216.85	0%
2016	12200	21,444,285.63	5%
	13214	2,052,260.06	1%
2018	12200	0.00	0%
	13214	2,234,802.67	1%

ANO	COBRADE	D&L US$	%
2022	13214	54,828,781.60	14%
2001 - 2022	**TOTAL US$**	**391,723,888.85**	**100%**

Fonte: Elaboração própria.

4 CONSIDERAÇÕES FINAIS

Com as análises foi possível confirmar que o evento ocorrido em 2022 foi um evento extremo meteorológico, sendo o mais severo das últimas décadas, estando associado com os maiores danos humanos registrados no município de Petrópolis. O estudo apontou indícios de que esse evento tenha ocorrido, entre outros fatores, em função de uma chuva concentrada em apenas um local, ponto este que carece de aprofundamento por pesquisas futuras.

O estudo não encontrou tendência significativa de alteração (positiva ou negativa) para os índices de chuvas mensais, RX1, RX5 ou anomalias climáticas para o município de Petrópolis. No entanto, é importante realizar estudos adicionais para verificar tendências de eventos extremos, usando séries temporais de precipitação de outros municípios na Região Sudeste ou considerando outras metodologias.

As análises também permitiram identificar que o evento de 2022 esteve associado com os maiores danos humanos registrados no município de Petrópolis. Em termos de danos humanos, 2005 e 2013 também podem ser considerados extremos, uma vez que excederam em muito a média anual, todos estes deflagrados por eventos pluviométricos.

Contrariamente à atribuição do desastre apenas ao alto volume pluviométrico, o estudo identificou poucos indícios de ações preventivas ocorridas anteriormente ao período chuvoso ou nos meses seguintes em prol da drenagem de água, reforçando a necessidade da melhoria da governança relacionada à redução do risco de desastres em curto, médio e longo prazo, ainda que esse tema não tenha sido aprofundado na pesquisa em questão. Além disso, existem evidências de descontinuidade dos programas de redução de risco de desastre no município que carece de maior atenção.

NOTA

1| O número de pessoas desaparecidas geralmente se transforma em número de óbitos.

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REFERÊNCIAS

ACCIARI, L.; RIBEIRO, M. **Risk, resilience and gender in the current Petrópolis tragedy**. UN Women, 2022. Available at: https://wrd.unwomen.org/explore/insights/risk-resilience-and-gender-current-petropolis-tragedy. Accessed on: 5 aug. 2023.

ALCÂNTARA, E. *et al*. **Deadly disasters in Southeastern South America**: flash floods and landslides of February 2022 in Petrópolis, Rio de Janeiro, Nat. Hazards Earth Syst. Sci. Discuss. Available at: https://doi.org/10.5194/nhess-2022-163, 2022.

ARAÚJO, L. M. N. *et al*. Avaliação da distribuição espaço-temporal histórica de eventos chuvosos no Rio de Janeiro. In: XIV WORLD WATER CONGRESS, 2011, Porto de Galinhas. **Proceedings** [...], 2010.

ASSUMPÇÃO, R. S. F. V. **Petrópolis – um histórico de desastres sem solução?** Do Plano Koeller ao Programa Cidades Resilientes. 2015. Tese (Doutorado em Ciências na área de Saúde Pública) – Escola Nacional de Saúde Pública Sérgio Arouca, Rio de Janeiro, 2015. Available at: https://www.arca.fiocruz.br/handle/icict/40233. Accessed on: 12 nov. 2022.

AVILA-DIAZ, A. *et al*. Assessing current and future trends of climate extremes across Brazil based on reanalyzes and earth system model projections. **Climate Dynamics**, v. 55, p. 1403–1426, 2020. Available at: https://doi.org/10.1007/s00382-020-05333-z.

BECK, Z. J. V. Meio ambiente e cidades resilientes: reflexões sobre o desastre em Petrópolis no ano de 2022. **Revista da Emerj**, v. 24, n. 2, p. 202–216. 2023.

BRASIL. Ministério do Desenvolvimento Regional. Secretaria de Proteção e Defesa Civil. Universidade Federal de Santa Catarina. Centro de Estudos e Pesquisas em Engenharia e Defesa Civil. **Atlas Digital de Desastres no Brasil**. Brasília: MDR, 2022. Available at: http://atlasdigital.mdr.gov.br/paginas/index.xhtml

BUNHAK, A. C. S.; WANDERLEY, H. S. Change in number of rainy days in the municipality of Visconde de Mauá, Rio de Janeiro. **Journal of Biotechnology and Biodiversity**, v. 8, n. 4. 2020. Available at: https://doi.org/10.20873/jbb.uft.cemaf.v8n4.bunhak

CABRAL, V. *et al*. The consequences of debris flows in Brazil: a historical analysis based on recorded events in the last 100 years. **Landslides**, v. 20, p. 511–529, 2023. Available at: https://doi.org/10.1007/s10346-022-01984-7

CAMARINHA, P. I.; DEBORTOLI, N. S.; HIROTA, M. **Índice de vulnerabilidade aos desastres naturais relacionados às secas no contexto de mudanças climáticas**. Produto II: Relatório com os resultados e discussões sobre o índice de vulnerabilidade e avaliação dos impactos relacionados às secas para as diferentes regiões do Brasil. Florianópolis: WWF Brasil. 2015.

CEMADEN; IBGE. **População em áreas de risco no Brasil**. 2018. Available at: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/tipologias-do-territorio/21538-populacao-em-areas-de-risco-no-brasil.html?=&t=acesso-ao-produto. Accessed on: 15 nov. 2022.

COSTA, J. *et al*. Validação dos dados de precipitação estimados pelo Chirps para o Brasil. **Revista Brasileira de Climatologia**, v. 24, jan-jul. 2019. Available at: http://dx.doi.org/10.5380/abclima.v24i0.60237

COSTA, A. A. *et al*. Precipitation extremes over the tropical Americas under RCP4.5 and RCP8.5 climate change scenarios: results from dynamical downscaling simulations. **International Journal of Climatology**, p. 1–17. 2022. Available at: https://doi.org/10.1002/joc.7828.

COUTINHO, S. M. V. *et al*. The Nexus+ approach applied to studies of Impacts, vulnerability and adaptation to climate change in Brazil. **Sustainability in Debate**, [s. l.], v. 11, n. 3, p. 24–56, 2020. DOI 10.18472/SustDeb.v11n3.2020.33514.

DEBORTOLI, N. S. *et al*. An index of Brazil's vulnerability to expected increases in natural flash flooding and landslide disasters in the context of climate change. **Nat Hazards**, v. 86, p. 557–582. 2017. DOI 10.1007/s11069-016-2705-2.

DOURADO, F.; ARRAES, T. C.; SILVA, M. O Megadesastre da Região Serrana do Rio de Janeiro – as Causas do Evento, os Mecanismos dos Movimentos de Massa e a Distribuição Espacial dos Investimentos de Reconstrução

no Pós-Desastre. **Anuário do Instituto de Geociências**, v. 35, n. 2, p. 43-54. 2012. Available at: http://dx.doi.org/10.11137/2012_2_43_54

FREITAS, M. A. S. Um sistema de suporte à decisão para o monitoramento de secas meteorológicas em regiões semiáridas. **Revista Tecnologia**, v. suplem, p. 84-95, 2005.

FUNK, C. *et al*. The climate hazards infrared precipitation with stations – a new environmental record for monitoring extremes. **Scientific data**, v. 2, n. 1, p. 1-21, 2015. Available at: https://doi.org/10.1038/sdata.2015.66

GRUBERTT, B. **Seis meses após tragédia em Petrópolis, famílias retornam para áreas de risco e obras de contenção ainda não foram realizadas**. G1, 15 ago. 2022. Bom Dia Rio. Available at: https://g1.globo.com/rj/rio-de-janeiro/noticia/2022/08/15/seis-meses-apos-tragedia-em-petropolis-familias-retornam-para-areas-de-risco.ghtml. Accessed on: 13 nov. 2022.

IBGE. Conselho Nacional de Estatística, Serviço Nacional de Recenseamento. **Censo Demográfico de 1940**. Available at: https://biblioteca.ibge.gov.br/visualizacao/periodicos/65/cd_1940_p15_rj.pdf. Accessed on: 18 nov. 2022.

IBGE. **População em áreas de risco no Brasil**. Rio de Janeiro: IBGE. 2018. 91 p.

IBGE. **Censo Demográfico 2010**. Rio de Janeiro, 2010. Available at: https://censo2010.ibge.gov.br/resultados.html. Accessed on: 14 nov. 2022.

IBGE. B**iomas e Sistema Costeiro Marinho do Brasil compatível com a escala 1:250.000**. Série Relatórios Metodológicos. 2019. Available at: https://www.ibge.gov.br/apps/biomas/#/home. Accessed on: 4 nov. 2022.

IBGE. **Cidades**. Available at: http://cidades.ibge.gov.br/. Accessed on: 8 nov. 2022.

IPCC. **Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation**. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [FIELD, C. B. *et al*. (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 2012. 582 p.

IPCC. **Climate Change 2021**: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V. *et al*. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 3–32. 2022. DOI 10.1017/9781009157896.001.

IPCC. **Climate Change 2022**: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [PÖRTNER, H.-O. *et al*. (eds.)]. Cambridge University Press. In Press. 2022. DOI 10.1017/9781009325844

KENDALL, M. G. **Rank Correlation Measures**. Ed. Charles Griffin. London. Lira, C. S. 1975.

LAHSEN, M.; RIBOT, J. Politics of attributing extreme events and disasters to climate change. **Wires Climate change**, v. 13. 2022. DOI 10.1002/wcc.750

MANN, H. B. Nonparametric tests against trend. **Econometrica: Journal of the econometric society**, p. 245-259. 1945.

MAPBIOMAS. **Mapeamento anual das áreas urbanizadas no Brasil entre 1985 e 2020**. 2021. Available at: https://drive.google.com/file/d/1cZ7KoUywnDcLAkokanjxoYmNAPffsVBW/view?usp=sharing. Accessed on: 28 nov. 2022.

MORAES, O. L. L. Proposing a metric to evaluate early warning system applicable to hydrometeorological disasters in Brazil. **International Journal of Disaster Risk Reduction**, v. 87, 13p. 2023. Available at: https://doi.org/10.1016/j.ijdrr.2023.103579

OSCAR JÚNIOR, A. C. Precipitation Trends and Variability in River Basins in Urban Expansion Areas. **Water Resour Manage**, v. 35, p. 661–674, 2021. Available at: https://doi.org/10.1007/s11269-020-02749-4

PAINEL BRASILEIRO DE MUDANÇAS CLIMÁTICAS. **Base científica das mudanças climáticas**. Contribuição do Grupo de Trabalho 1 do Painel Brasileiro de Mudanças Climáticas ao Primeiro Relatório da Avaliação Nacional sobre Mudanças Climáticas [AMBRIZZI, T.; ARAÚJO, M. (eds.)]. COPPE. Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil, 464 p. 2-14. 2014.

PRABHAKAR, S. V. R. K.; SRINIVASAN, A.; SHAW, R. Climate change and local level disaster risk reduction planning: need, opportunities and challenges. **Mitig Adapt Strateg Glob Change**, v. 14, p. 7–33. 2009.

PREFEITURA MUNICIPAL DE PETRÓPOLIS. **Plano Municipal de Redução de Risco (PMRR)**: 1ª (Revisão), 2º, 3º, 4º e 5º Distritos – Petrópolis, RJ - Programa de Urbanização, Regularização e Integração de Assentamentos Precários – 6a Etapa Reflexão e Proposição de Estratégias de Intervenções não estruturais para a Redução do Risco. Petrópolis: Prefeitura Municipal de Petrópolis (PMP) – Secretaria de Habitação (SEH), 2017. Available at: https://sig.petropolis.rj.gov.br/cpge/Reflexoes.pdf. Accessed on: 30 oct. 2022.

ROOY, M. P. V. A rainfall anomaly index independent of time and space. Notes. **Weather Bureau of South Africa**, v. 14, p. 43-48, 1965.

ROZANTE, J. R. *et al*. Combining TRMM and Surface Observations of Precipitation: technique and validation over South America. **Weather and Forecasting**, v. 25, p. 885-894, 2010.

SERVIÇO GEOLÓGICO DO ESTADO DO RIO DE JANEIRO. **Cartografia Geotécnica de Aptidão Urbana, 1:10.000 de Petrópolis a "CGU do DRM"** – junho/2015 – Relatório Técnico. 73 p. 2015.

SILVA, S. V. C. da. *et al*. Modelagem bayesiana da precipitação máxima de Petrópolis (RJ) e Poços de Caldas (MG). **Engenharia Sanitária e Ambiental**, v. 28, 2023. Available at: https://doi.org/10.1590/S1413-415220210342

SILVA, F. P. *et al*. Identification of rainfall and atmospheric patterns associated with Quitandinha River flooding events in Petrópolis, Rio de Janeiro (Brazil). **Nat Hazards**, v. 103, p. 3745–3764, 2020. Available at: https://doi.org/10.1007/s11069-020-04153-y

STOTT, P. A. *et al*. Attribution of extreme weather and climate-related events. **Wiley Interdisciplinary Reviews**: climate change, [s. l.], v. 7, n. 1, p. 23–41, 2016. DOI 10.1002/wcc.380.

TORRES, G. P.; CARMO, L. F. R.; PALMEIRA, A. C. P. Estudo da relação entre precipitação e deslizamentos no município de Petrópolis-RJ. **Revista S&G**, n. 15, 2020.

VILLARINI, G. *et al*. Examining flood frequency distributions in the midwest U.S. **Journal of the American Water Resources Association**, v. 47, n. 3, p. 447-463, 2011. Available at: https://doi.org/10.1111/j.1752-1688.2011.00540.x

Bringing to light a new energy path: the case of the state of Minas Gerais, Brazil

Trazendo à luz um novo caminho energético: o caso de Minas Gerais, Brasil

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ABSTRACT

In Brazil, more than 55% of the energy comes from hydroelectricity, making the system highly vulnerable in the context of global climate change, with precipitation and temperature shifts over the years. Characterised by its multiple opportunities in sources and conversion technologies for energy, biomass has a high potential to become responsible for a relevant share of the renewable energy supply. Previous studies on biomass energy production in Brazil confirm promising results. This paper highlights possibilities for biomass power generation in Minas Gerais State. To estimate energy productivity, a Sustainable Technical Coefficient was adopted: a conservative index that considers the portion of residues that could be used to maintain the integrity of the soil. This index was applied with the data on silviculture and selected crop yields. The local energy demand was also calculated and compared to the potential energy production. Results show that 78% of the municipalities could have their basic energy needs and 18% of the demand for productive uses met by crop residues and silviculture production. For the state of Minas Gerais, with its tradition of agriculture, biomass residual energy is viable and should be considered by policymakers.

Keywords: Biomass energy. Sustainable development. Renewable energy. Energy potential.

RESUMO

No Brasil, mais de 55% da energia provém de hidroeletricidade, tornando o sistema altamente vulnerável no contexto das mudanças climáticas globais, com alterações na precipitação e temperatura ao longo dos anos. Caracterizada por suas múltiplas possibilidades de fontes e tecnologias de conversão para energia, a biomassa possui um alto potencial para se tornar responsável por uma parcela relevante no fornecimento de energia renovável. Estudos anteriores sobre a produção de energia a partir de biomassa no Brasil confirmam resultados promissores. Este artigo destaca as possibilidades para geração de energia a partir de biomassa no estado de Minas Gerais. Para estimar a produtividade energética, adotou-se um Coeficiente Técnico Sustentável: um índice conservador que considera a porção de resíduos que poderia ser utilizada mantendo a integridade do solo. Esse índice foi aplicado juntamente com os dados de silvicultura e rendimento de culturas selecionadas. A demanda local de energia também foi calculada e comparada com o potencial de produção desta. Os resultados mostram que 78% dos municípios poderiam suprir suas necessidades básicas de energia e que 18% da demanda

para usos produtivos poderia ser atendida pelos resíduos da produção agrícola e da silvicultura. Para o estado de Minas Gerais, com sua tradição agrícola, a energia residual proveniente da biomassa é viável e deve ser considerada pelos formuladores de políticas públicas.

Palavras-chave: Energia de biomassa. Desenvolvimento sustentável. Energia renovável. Potencial energético.

1 INTRODUCTION

Brazil presents a unique model for the energy sector's structural development: having advanced in hydropower technology since the 19th century, which has dominated the country's energy matrix since the 1970s. During this period, several supply crises were faced. The most severe occurred in 2001 when general blackouts began. This marked a turning point in the country, with the resumption of energy projects to guarantee the supply of energy to the population. Interestingly, the source of most of this energy remained the same: hydroelectricity (GOMES *et al*., 2002). The two biomes with the highest levels of species endangerment and fragmentation, the Cerrado and Amazon (OLIVEIRA *et al*., 2017; VEDOVATO *et al*., 2016), contain about 70% of the potential for hydropower production (FERREIRA *et al*., 2014). The negative impacts of the projects on the way of life of local communities on the river's surroundings and nature are hard to avoid. Regardless of the Brazilian Environment Agency requiring specific conditions and limitations for the execution of such projects, the dam's construction continued to defy these restrictions and create irreparable impacts on the environment and social areas (ABRAMOVAY, 2014; FEARNSIDE, 2009; FEARNSIDE; PUEYO, 2012; FUCHS, 2016; WINEMILLER *et al*., 2016). Moran *et al*. (2018) point out that without considering the real social, environmental and cultural costs involved in the water dams construction, it cannot be considered a sustainable energy source. Dávalos, Rodrigues Filho and Litre (2021) offered a comprehensive discussion not only on how the dams have impacted the way of life of indigenous communities but also on the necessity of considering their knowledge when formulating public policies.

In a country such as Brazil, where hydro energy represents not only the highest share in the energy matrix but also a fragile energy source in a climate change context, the assessment of alternatives that minimise environmental impacts, promote the sustainable development of the population, and guarantee the energy security should be seriously considered. According to (RIBEIRO; RODE, 2016), the state of Minas Gerais in Brazil presents favourable characteristics for developing biomass energy initiatives. The authors conducted an analysis to find ideal regions to develop new biomass energy initiatives, considering the local demand, transmission lines, existing energy sources and environmental constraints (land use and environmental preservation factors). The state of Minas Gerais presented a higher potential to develop a biomass energy initiative, respecting the environmental fragilities and its regulations.

This paper assesses an estimation of the regional potential from Minas Gerais state for energy production from biomass residues; recommendations from literature for how much residue could be removed without damaging the soil are also considered. This potential energy production is compared to the local energy demand. We aimed to answer the following questions: 1) How much energy from residues can be produced sustainably without compromising the soil? And 2) Can sustainable potential meet the local energy demand?

2 BACKGROUND

Brazil has experienced precipitation and temperature shifts in the context of global climate change over recent years. Considering the lack of seasonality in Brazil, the impact of these shifts on electricity generation has been massive and has negatively impacted the population's quality of life. More than 55% of the energy for the whole country comes from hydroelectricity, obtained from a mix of energy sources

that makes the system highly vulnerable (Figure 1) (EPE, 2022). Without investment in the sector, the necessary amount of water, and alternative sources of clean energy, the country is more dependent than ever on natural gas thermoelectric energy generation as an alternative to meet its demand (WELFLE, 2017). This makes the system expensive and harmful to the environment (GOMES, 2014).

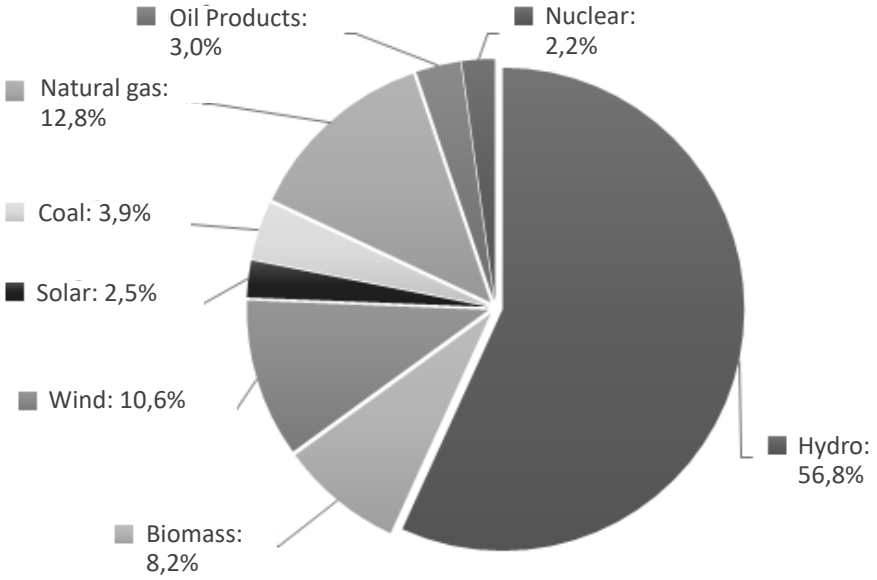

Figure 1 | Domestic electric supply by source

Source: (EPE, 2022).

A relevant change in the energy sector requires investment, legislative and organisational changes, combining environmental considerations and a set of multi-criteria local planning and public participation (HAAREN *et al*., 2012). According to Abramovay (2014), despite being responsible for a small share of the world's energy matrix (3%), the increasing use of modern renewable energy sources (solar, wind, geothermal and modern biomass) lean towards exponentially lowering their costs and thus, make them more generally accessible. A distributed energy production system from renewable technologies would be able to provide a central source of renewable environmental-friendly energy.

Biomass energy is characterised by its diverse sources and conversion technologies for energy, presenting a relevant potential for supply through renewable energy. Biomass includes plant material produced through photosynthesis and all its by-products, such as cultivated crops, forest wood, animal manures, and organic matter (VIDAL; HORA, 2011). A considerable amount of research has already been developed on the topic of cleaner, cheaper and accessible energy sources in a diverse sort of regions such as Peru (LILLO *et al*., 2015), Spain (DÍAZ-CUEVAS; DOMÍNGUEZ-BRAVO; PRIETO-CAMPOS, 2019), Italy (PALMAS *et al*., 2012), Saudi Arabia (ABDEL DAIEM; SAID, 2022), Greece (SKOULOU *et al*., 2011), Germany (PALMAS; SIEWERT; VON HAAREN, 2015), China (SHAPIRO-BENGTSEN *et al*., 2022), South Africa (BATIDZIRAI *et al*., 2016) and Southern Asia (BHATTACHARYYA, 2014), as some examples of the many researches present different methods to explore the best opportunities for renewable energy generation. Responsible for 8,2% of the energy supply in Brazil (EPE, 2022), previous studies on biomass energy production conclude that it is an option that should be considered in developing the country's energy sector. A national-wide methodology was presented in the Brazilian Atlas of Bioenergy (COELHO; MONTEIRO; KARNIOL, 2012). There, it was considered residual energy production from agriculture and silviculture activities, liquid swine sewage and solid urban waste in sanitary landfills. Maps were used to present the results to each region of the country, considering different conversion efficiency scenarios.

The Brazilian Energy Research Office produced the Rural Residues Energetic Inventory (EPE, 2014) to explore the potential as an energy source from agriculture, agroindustry and livestock residues. A summary of different sources was presented, detailing the agriculture production and the estimation of its residues. Considering different conversion technologies, a potential of 48 million tonnes for agriculture and livestock waste was estimated regarding the technical potential for biomethane and energy production.

Another example of biomass energy potential assessment in Brazil is the Biomass Residues as Energy Source to Improve Energy Access and Local Economic Activity in low HDI regions of Brazil and Colombia (BREA Project) (GBIO *et al*., 2015). A cooperative effort between Brazilian and Colombian scientists presented a complete data set on energy generation from residues. The target of the study was to "develop a better knowledge of energy requirements for productive purposes among poor households in urban and rural areas of Brazil and Colombia (many of them in isolated regions), which could allow inputs for targeted policy interventions" (GBIO *et al*., 2015). The methodology encompassed an assessment of different conversion technologies, potentials, policies, scenarios, and barriers to the development of bioenergy for 32 municipalities in the Brazilian Amazonian region.

Regarding other renewable energy sources, biomass energy requires needs the major area per produced energy unit (BLASCHKE *et al*., 2013b), and it could be related to a potential conflict with other land uses (SÖDERBERG; ECKERBERG, 2013). Without considering careful planning, the competition between biomass energy, conservation, agriculture, and forestry is inevitable (BLASCHKE *et al*., 2013a). Concerning sustainability, any enterprise that seeks biomass as a source of power must guarantee soil health, biodiversity and the water cycle, lowering the negative impacts in the long term.

One alternative for minimising the negative environmental impacts of biomass use and ensuring sustainability is to produce energy from cultivation residues, thereby bringing more opportunities to the local population. Several agricultural systems base their natural cycle on nutrient recycling, where part or certain residue of the main crop is left on the soil to protect it physically from rain, sun, and wind and to nurture soil biota. Crop residue retention is, in fact, one of the three pillars of Conservation Agriculture (HOBBS; SAYRE; GUPTA, 2008; SOMMER *et al*., 2018). This measure can avoid the necessity of fertiliser input, protect against soil degradation, and increase carbon sequestration in the soil. However, some studies point out there is no need to place all the residues on the soil. In some cases, a proportion can be removed without causing harm to the integrity of the soil (DIAS *et al*., 2012; EPE, 2014; FOELKEL, 2016).

The Brazilian electrical distribution sector is mainly divided by state. Until the early 1990s, most state governments owned companies that provided the local operations on the energy distribution system (TOVAR; RAMOS-REAL; ALMEIDA, 2010). This condition changed with the privatisations that came along to reduce the debt of a system that experienced rapid growth during the 1960s and 1970s and culminated in a profound crisis in the 1980s (ALMEIDA; PINTO JÚNIOR, 2000; LORENZO, 2002; TOVAR; RAMOS-REAL; ALMEIDA, 2010). The privatisation wave did not reach the state of Minas Gerais, where the same company, Cemig (Minas Gerais Energy Company), is responsible for the concessions of 96% of the state. Cemig also figures as one of the few companies in the country that join the tasks of generation, distribution, transmission, and commercialisation of energy (CEMIG, 2012).

Considering the necessity of choosing a study area, the state unit appears as the most appropriate option since, besides having uniformity in the electric system, it also presents a political management unit that facilitates the creation and application of policies. The state of Minas Gerais has favourable environmental and economic characteristics for the development of this study. Therefore, it has been elected as the focus area of this paper.

Given the context of climate change and the fragility of Brazil's energy matrix in the face of these changes, it is important to analyse the self-sufficiency in sustainable bioenergy of a federative unit with the fourth-largest territorial area in the country, the second-highest population, and the largest number of municipalities in the country (IBGE, 2023) This analysis aims to shed light on potential new directions that can guide decision-making regarding the sustainable diversification of the Brazilian energy matrix.

3 MATERIAL AND METHODS

3.1 DEFINITION OF THE STUDY AREA

Drawing from the findings Ribeiro and Rode (2016, 2019) presented, a focal area for conducting the study needed to be selected. Among the options, the state of Minas Gerais (Figure 2) exhibited the highest potential in the country for establishing the groundwork for a biomass energy initiative while adhering to environmental regulations.

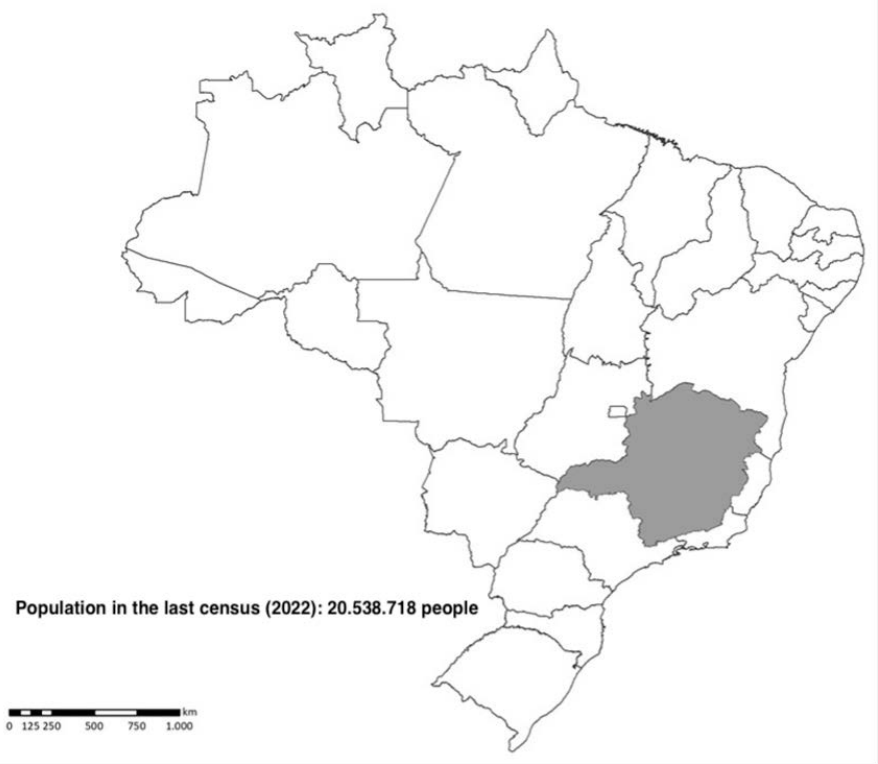

Figure 2 | The state of Minas Gerais

Source: (IBGE, 2019, 2023).

Minas Gerais gained importance during colonial times, mainly from the wealth coming from its abundance of gold. With the exhaustion of these sources and the decline of the mining industry in the early nineteenth century, agriculture emerged as an important economic activity of the region. Considered by some authors as a period of stagnation and decay, the exhaustion of the gold mining activity left society more diverse and one which demanded different agricultural products. This led to the structuring of a productive and commercial sector that aimed to meet these internal demands (SOUZA, 2013).

The industrial sector is the second largest in the Minas Gerais economy, accounting for about 29.5% of the state's GDP (IBGE, 2017a), with the iron mining industry leading this economic sector. The state also

stands out in producing automobiles, steel products, cement, chemicals, and food. Minas Gerais also presents the third-largest economy in Brazil, participating with approximately 8.7% of the Brazilian GDP, behind only the states of São Paulo and Rio de Janeiro (IBGE, 2017a). The primary agricultural goods produced are coffee, sugar, milk, various types of meats, soy, corn, and beans. In 2022, agribusiness exports reached US$ 15,3 billion, corresponding to 9,6% of Brazilian agribusiness exports (MAPA, 2023; SEAPA, 2023). In this mineral and agricultural wealth context, the state presents an average Human Development Index higher than the country's total average (Table 1).

Table 1 | HDIs from Brazil and Minas Gerais compared

	Brazil	*Minas Gerais*
HDI (Total)	0,761	0,769
HDI Income	0,729	0,731
HDI Longevity	0,841	0,866
Life expectancy at birth (years)	75,44	76,97

Source: FJP (2018).

In the environmental area, Minas Gerais has three of the six Brazilian biomes: the Cerrado (Brazilian savannah), the Atlantic Forest and a small portion of the Caatinga (dry forest). This encounter of different environments creates transition areas that are extremely rich in biodiversity and environmental specificities.

The selection of the state of Minas Gerais as the focal point of this paper is grounded in identifying ideal conditions characterised by uniformity in administrative aspects (e.g., consistent laws, financial conditions, taxes, and support agencies) and in the electricity sector (uniform regulations). An evaluation of the potential, as outlined by Ribeiro and Rode (2016), solidified the state of Minas Gerais as the optimal choice for this investigation due to its favourable conditions. The analyses were conducted considering municipal-level data, as this is the format in which data are presented in the national database. Nonetheless, certain regions within the state are referenced in the analyses due to their potential. However, it is not the aim of this research to delve into the historical economic development of the state or explore its potential.

3.2 PRODUCTIVITY DATA ANALYSIS

In order to assess the distribution of biomass residues in the state of Minas Gerais from annual crops, permanent crops, and silviculture production was downloaded from the governmental Sidra (SIDRA; IBGE, 2015a) platform. For annual and permanent crops, data was collected considering the crops produced in the entire state area, some predominantly in a large-scale agricultural model (corn, sugarcane, and coffee) and others more commonly in a family production model (manioc). Municipalities that had a biomass production rate (selected crops and silviculture) higher than 1,000 tonnes per year in the last agriculture census were selected to be analysed. This intended to calculate the potential for municipalities where the yield would make installing an energy production unit worthwhile. The chosen crops were coffee, corn, beans, manioc, and sugarcane. The assessment of production data is important for estimating the amount of residues generated during the production process. The literature indicates a percentage of the remainings from harvesting or primary processing for all the crops.

For the silviculture, we selected data pertaining to the production of eucalyptus charcoal, firewood and wood in 2016. To ensure the sustainability of the process, data regarding wood products from native vegetation was not considered in this study. Of 853 municipalities in the state of Minas Gerais, 804 met the conditions and were analysed.

The maintenance of current land use was presupposed for all the energy sources. Considering that the state of Minas Gerais has around 30% of its original vegetation cover (CARVALHO *et al*., 2008), this research estimates an energy production that excludes the conversion of preserved areas into agriculture or silviculture areas. Another principle followed was to guarantee that the competition of uses between energy and food would not occur, ensuring productivity and sustainability (RIBEIRO; RODE, 2016).

Considering soil integrity as a main necessity for the continuation of production activities for crops and silviculture, the recommendations in the literature regarding the percentage of the residues that should be left in the field for soil recovery were followed. To estimate energy productivity, a Sustainable Technical Coefficient (TCS) was adopted (see Table 2). The Traditional Technical Coefficient (TCT) represents the proportion of residues within the total yield (COELHO *et al*., 2015). For each of the crops and wood, literature was found indicating how much could be used to maintain the integrity of the soil. For most of the sources, a percentage indicated by studies in Brazil as Dias *et al*. (2012), EPE (2014) and Foelkel (2016), adequate for tropical conditions, was adopted. Only for the case of coffee, as no specific literature was present, a generalist recommendation of leaving 70% in the soil was assumed. Even though it may be considered a conservative value, removing a minor amount of residues aims to avoid solving one problem by creating another (soil degradation). Conservation tillage has proven effective for soil and environment conservation (BUSARI *et al*., 2018). In this paper, it was considered that the guarantee of supply for bioenergy production depends directly on soil productivity. A lower amount of organic matter in the soil can be more damaging to productivity than its excess. Thus, a more conservative coefficient was adopted in order to guarantee sustainability. Table 2 represents the values of TCS used in the calculation.

Table 2 | Traditional Technical Coefficient and Sustainable Technical Coefficient

Source	*Type of residue*	*Traditional Technical Coefficient (TC_T)*	*Percentage left on the soil*	*Sustainable Technical Coefficient (TC_S)*
Coffee	Husk	1.00	70%	0.30
Sugarcane	Straw	0.20	50%	0.10
Beans	Husk	1.16	60%	0.45
Manioc	Aerial	0.65	60%	0.25
Corn	Stover	1.68	60%	0.65
Eucalyptus	Primary processing	0.25	20%	0.20

Source: Dias et al. (2012), EPE (2014), Foelkel (2016) and authors' calculations

The TC_T and TC_S for beans, manioc and corn, were found on (EPE, 2014). For sugarcane, the coefficients adopted were from (Dias *et al*., 2012). For the eucalyptus, less literature was found regarding the use of residues. A relevant portion of the residues corresponds to the litter, representing an important share of the nutrient cycling process. Foelkel (2016) recommends that litter, leaves, and small branches are indispensable for maintaining soil fertility. Therefore, only the residues from the harvests (primary processing) were considered. Specific data on the availability of each source and its proportion to be considered in the calculation can be seen in Table 3.

Table 3 | Availability of each source and sustainable proportion considered for energy conversion

Source	*Total yield (ton/ year)*	*Sustainable Technical Coefficient(TC_S)*	*Available residues (ton/year)*
Coffee	1,303,681	0.30	391,104
Sugarcane	71,080,882	0.10	7,108,088
Beans	569,466	0.45	256,260

Source	Total yield (ton/ year)	Sustainable Technical Coefficient(TC_s)	Available residues (ton/year)
Manioc	844,122	0.25	211,031
Corn	6,947,837	0.65	4,516,094
Wood	12,388,720	0.20	2,477,744

Source: Sidra e IBGE (2015a, 2015b) and authors' calculations

We applied different formulas to different sources to calculate the potential for energy production from biomass residues in the state of Minas Gerais or the amount of energy that could be produced considering losses in the process. All the formulas were used by Coelho *et al*. (2012) for the Brazilian Bioenergy Atlas. These calculations show how biomass energy is distributed in the state per source.

- **Crops:** the conversion efficiency adopted for the residues was 15% of the low thermodynamic yield - 20 bar boiler compound systems, atmospheric condenser turbine (COELHO; MONTEIRO; KARNIOL, 2012).

$$Potential\ (MW/year) = \frac{\left[(Crops_{tons} \times TC) \times LHV_{kcal/kg} \times 0.15\right]}{(860 \times 8{,}322_{hours})}$$

Where:

- Cropstons: total of harvested crops in a year
- TC: technical coefficient
- LHV: lower heating value
- 0.15: 15% conversion efficiency
- 860: conversion factor from kcal/kg to kWh/kg
- 8,322: working hours per year (considering that the energy would be produced in 95% of the year hours. This factor converts the results from Megawatt hour to Megawatts per year).

- **Sugarcane:** as the calculation was made for simple systems, the lower energetic yield of 30 kW/sugarcane tons was considered.

$$Potential\ (MW/year) = \frac{\left(Sugarcane_{tons} \times 30_{kWh/ton}\right)}{(1{,}000 \times 5{,}563_{hours})}$$

Where:

- $Sugarcane_{tons}$: total of harvested sugarcane in a year
- $30_{kWh/ton}$: energetic yield of sugarcane in cogeneration systems
- 1,000: conversion from kW to MW
- 5,563: working hours from April to November (considering the harvesting time). This factor is important to convert the results from Megawatt hour to Megawatts per year)

- **Wood:** the calculation of the potential considered for a conventional steam turbine system (Rankine cycle) with yields of 15%, considering a small-sized system.

$$Potential\ (MW/year) = \frac{\left[(Wood_{tons} \times TC) \times LHV_{kcal/kg} \times 0.15\right]}{(860 \times 8{,}322_{hours})}$$

Where:

- $Wood_{tons}$: total of harvested wood in a year
- TC: technical coefficient, proportion of residues in the total yield
- LHV: lower heating value
- 0.15: 15% conversion efficiency
- 860: conversion factor from kcal/kg to kWh/kg
- 8,322: working hours per year (considering that the energy would be produced in 95% of the year hours. This factor converts the results from Megawatt hour to Megawatts per year)

All the calculations were made considering a viable technology: a cheap technology with low conversion efficiency (15%). Considering that investing in sustainable energy to improve people's lives is not necessarily an attractive business, even more in the context of economic crisis. A modern and expensive technology with a higher conversion coefficient would be unlikely to be financed.

3.4 DEMAND CALCULATION

The energy ladder from Coelho and Goldemberg (2013) was adopted to estimate the potential energy demand in the municipalities for two distinctive phases: (1) First phase: basic energy needs (lighting, cooking, and heating), which would necessitate about 50 - 100 kWh per person per year, (2) Second phase: productive uses (water pumping, irrigation, agricultural processes, heating, and cooking), which would necessitate about 500 – 1,000 kWh per person per year.

As presented by Coelho *et al*. (2015), low and high electricity requirements were calculated based on the following formulas:

- First phase (basic human needs)

$$Electricity\ demand_{(low)} = number\ of\ inhabitants \times access\ rate_{(\%)} \times 50\ kWh$$

$$Electricity\ demand_{(high)} = number\ of\ inhabitants \times access\ rate_{(\%)} \times 100\ kWh$$

- Second phase (productive uses)

$$Electricity\ demand_{(low)} = number\ of\ inhabitants \times 500\ kWh$$

$$Electricity\ demand_{(high)} = number\ of\ inhabitants \times 1{,}000\ kWh$$

For both phases, an average value of electricity demand was measured for the results. This was calculated by taking the mean of the low and high values:

$$Electricity\ demand_{(average)} = \frac{(Electricity\ demand_{(low)} + Electricity\ demand_{(high)})}{2}$$

The energy ladder from Coelho and Goldemberg (2013) was adopted to estimate the potential energy demand in the municipalities for two distinctive phases: (1) First phase: basic energy needs (lighting, cooking, and heating), which would necessitate about 50 - 100 kWh per person per year, (2) Second phase: productive uses (water pumping, irrigation, agricultural processes, heating, and cooking), which would necessitate about 500 – 1,000 kWh per person per year.

As presented by Coelho *et al*. (2015) and applied by Ribeiro and Rode (2019), low and high electricity requirements were calculated.

4 RESULTS

Of 853 municipalities in the Minas Gerais state, only 49 did not reach the minimum production rate of 1,000 tonnes per year in the last agriculture census to integrate the analysis. As a result, the analysis focuses on 804 municipalities that reached the stipulated value.

4.1 ENERGY POTENTIAL

Minas Gerais is a state where agriculture represents one of the strongest local activities, ranging from large-scale monoculture farms to traditional family subsistence farming (IBGE, 2009). The energy potential from annual crop residues (Figure 3) had the highest results from all the sources, reaching values up to 60 MW with the yearly harvesting per municipality. The west sub-region, Triângulo Mineiro, had the best result due to the dominance of modern large-scale agribusiness. This sub-region is the state's main producer of sugarcane and corn (BASTOS; GOMES, 2011).

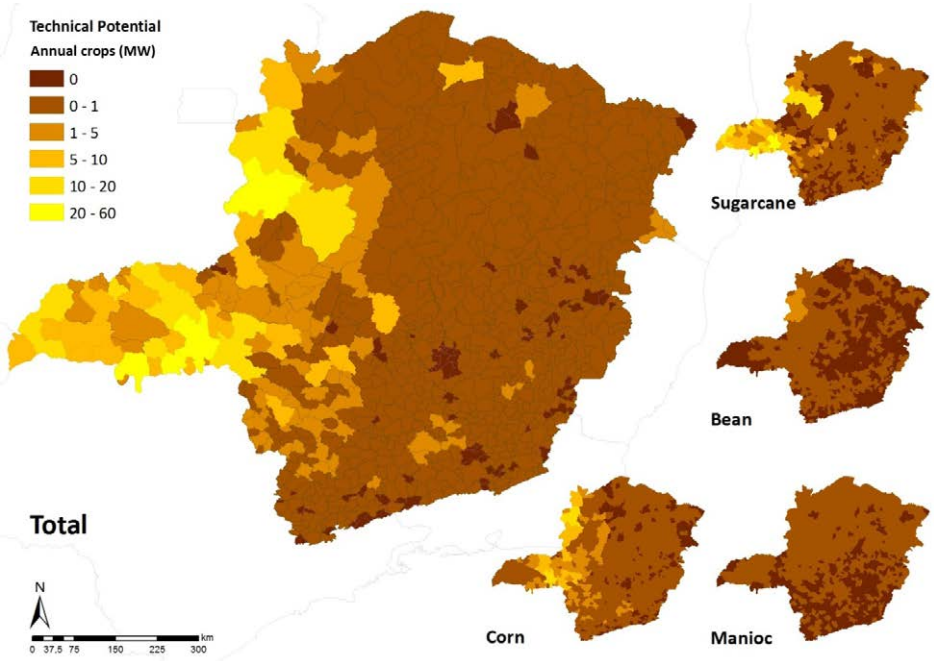

Figure 3 | Sustainable technical potential of energy production from annual crop residues with the yearly harvest per municipality

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

Standing out as Brazil's largest producer and exporter of coffee, the state of Minas Gerais is responsible for more than 50% of the country's production. Even though the residues of coffee production alone show results varying from 0.1 to 1.5 MW (Figure 4), the results are considerably lower than those of energy production from annual crop residues.

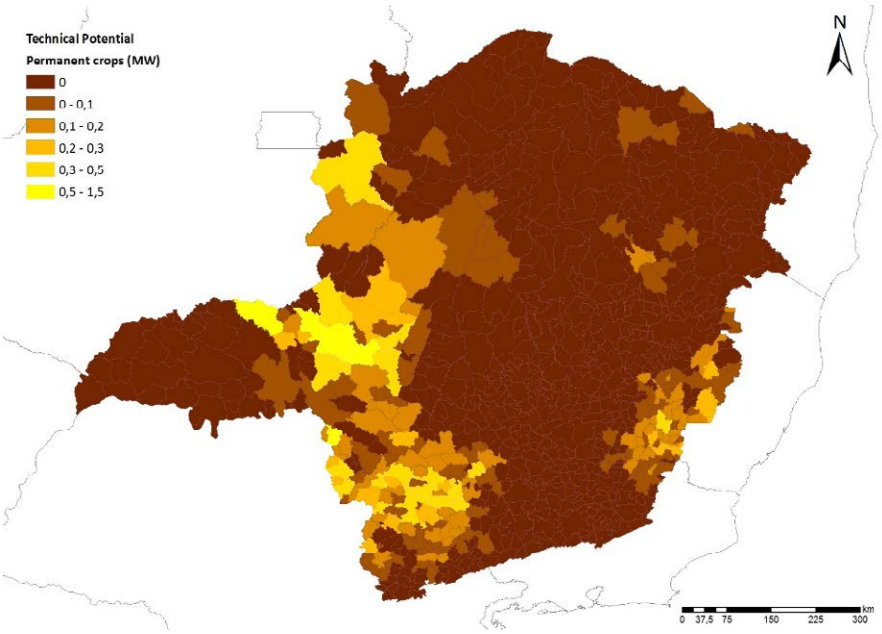

Figure 4 | Sustainable ttechnical potential of energy production from coffee residues with the yearly harvest per municipality

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

The state of Minas Gerais also has a strong silviculture sector. Having its origins in the steel and iron industries' stimulation in the 1970s by the military dictatorship (1964-1985), the lack of coal to fire the sector was presented as an impediment. An incentive project was created, giving a 50% tax reduction to private owners and companies willing to invest in silviculture (CALIXTO *et al.*, 2009). This marked the beginning of the development of the eucalyptus sector in the country. By 2016, more than 2 million tonnes of wood were produced yearly in Minas Gerais (SIDRA; IBGE, 2015b). In the more productive areas, the estimation of the potential energy production from silviculture residues (Figure 5) could reach up to 8 MW with the annual yearly harvest per municipality.

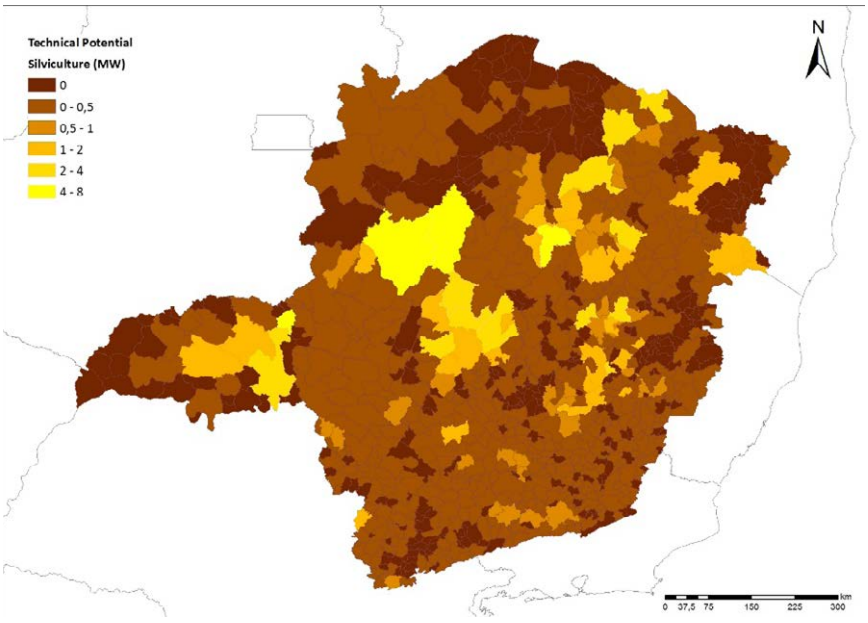

Figure 5 | Sustainable technical potential of energy production from silviculture residues with the yearly harvesting per municipality

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

The combination of the values presented in the scenario generated above, where the most fruitful areas of the state would reach a value of the total sustainable technical potential for energy production of up to 65 MW with the yearly harvest per municipality (Figure 6).

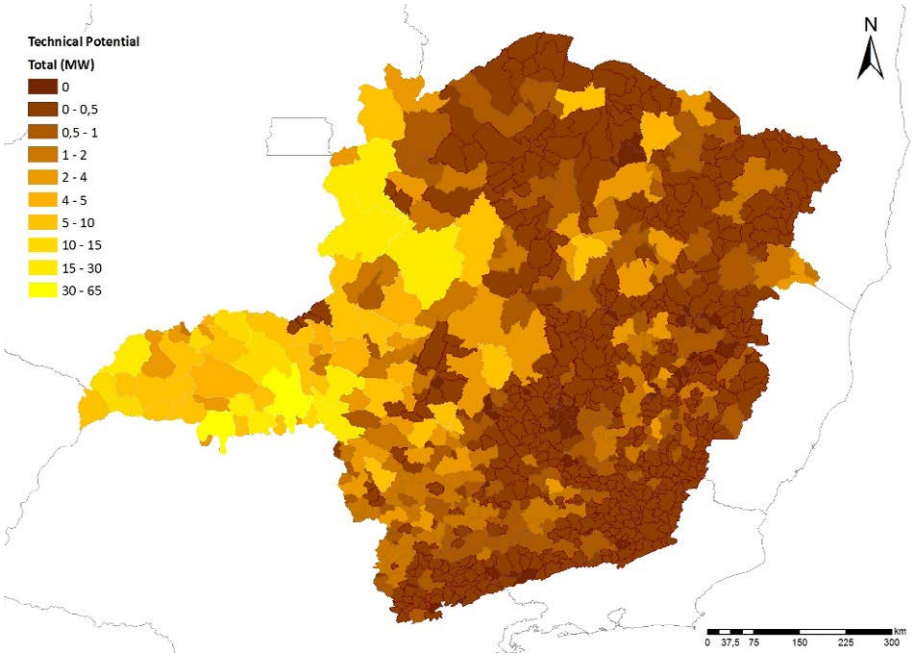

Figure 6 | Sustainable technical potential of energy production from all agriculture residues with the yearly harvest per municipality

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

In total, within all the accessed sources, the annual crops show the highest potential in the state of Minas Gerais, reaching a total of 6,495 GWh/year. This reflects the consolidated agriculture industry in the state, mainly in the West. The permanent crops have the smallest value: 259 GWh/year. The results are interesting because the only permanent crop type accessed was coffee. The silviculture potential shows a more distributed result, with no concentration in one specific state region and reaching 1,409 GWh/year.

4.2 DEMAND VS PRODUCTION

To evaluate if the sustainable energy potential could meet the local energy demand, the potential future energy demand for basic needs and productive uses was calculated and compared to the sustainable technical potential (Figures 7 and 8).

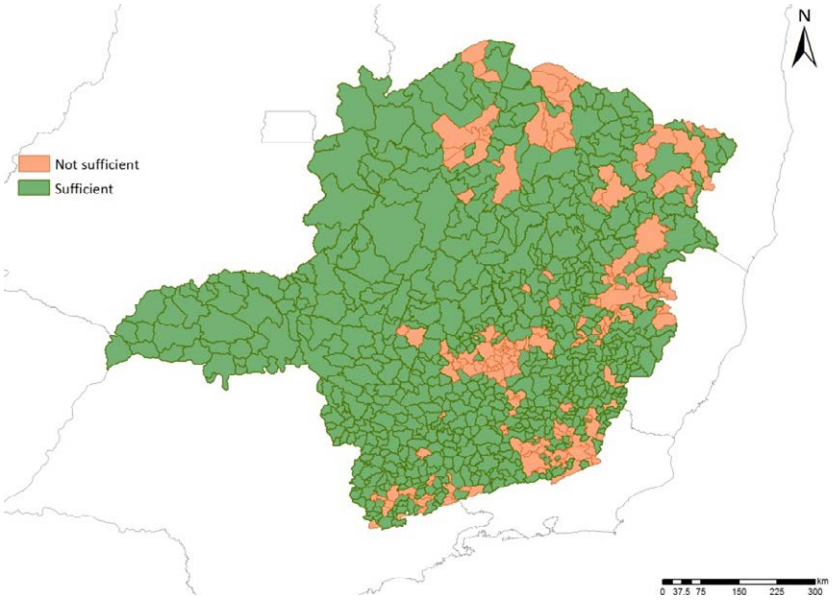

Figure 7 | Demand vs. production in a scenario of basic needs

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

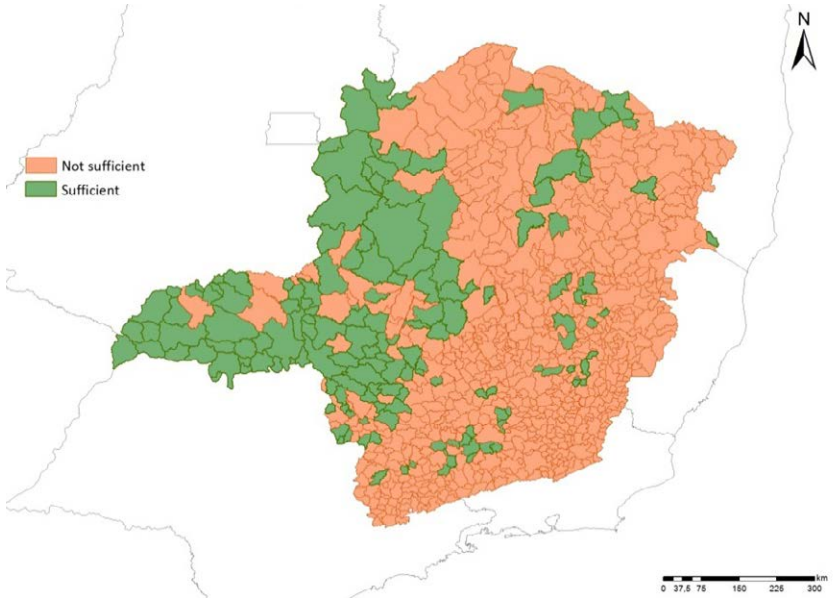

Figure 8 | Demand vs. production in scenario of productive uses

Source: IBGE (2009), IBGE (2019), Sidra (2015) and authors' calculations

The municipalities where the demand was met in the basic needs scenario reached 79% of the total (Table 4) and 83% of the analysed municipalities. Most places where the results were insufficient represent large metropoles with no space for agriculture and high energy demand. The large municipalities that could meet the energy demand in a productive use scenario are those with the greatest yield in the state. Many of them are in the municipalities where the agribusiness is concentrated and the highest GDP in the state is located.

Table 4 | Synthesis of the results of demand vs. production

		Basic Needs		*Productive Uses*	
Municipalities	Sufficient	670	78%	157	18%
	Not sufficient	134	16%	647	80%
	Not analysed	49	6%	49	6%

Source: Authors' calculations

5 DISCUSSION

For the scenario of basic needs for the whole state, a surplus of 6,704 GWh/year was estimated. One possibility for optimisation is the exportation of residues from regions with energy surplus to places where the agricultural and silviculture residues cannot cover the demand. Another option to be exploited is the transformation of the surplus into pellets: a dry, compact and small portion of biomass that is easily stored and transported. This alternative could be a solution to meet the demand for areas with lower residues and generate income for the places with additional residues. A Brazilian law resolution from 2015 (National Electricity Agency – Aneel 687/15) began to facilitate the process of decentralised energy production, regulating the distribution of micro and mini energy generation. Therefore, creating an ideal context for developing small energy generation units.

According to the Brazilian Institute of Geography and Statistics (IBGE), Minas Gerais is a state with the fourth biggest territory in the country and the second largest in terms of inhabitant numbers, with a population of 20,538,718 inhabitants in 2022 (IBGE, 2023). Of the 853 municipalities, 32 have large cities (more than 100 thousand inhabitants) and hold 45% of the state's population. Those populated municipalities have more capacity to increase the energy demand and less area to produce agriculture and residues. These municipalities are responsible for 12% of the energy potential and, as calculated based on the population, 45% of the energy demand. This unbalanced relation means 11 of those 32 municipalities meet the demand on a basic needs scenario and only one on a productive uses scenario. (PALMAS *et al*., 2015) investigated the regional potential for the ideal renewable energy mix in Germany. Such research has not been carried out yet in Brazil and could be the next step to creating a sustainable energy system for Minas Gerais. As assessed in this paper, biomass could supply 78% of the demand for basic needs and 18% of the energy in a scenario of productive uses (Table 5). An ideal sustainable energy mix, including other sources such as solar and wind energy or even biomass from urban solid waste, could reduce the risk of energy shortages and blackouts and contribute to a clean and safe energy matrix.

It is important to remark that the demand calculation is based on the essential needs of a household, so the amount of energy estimated does not reflect the modern patterns of energy consumption. The energy from residues could be directed to the low-income population, focusing on the rural area where it is produced, improving locally produced goods, andaising attractiveness for new local businesses (VENGHAUS; ACOSTA, 2018). Investments in education and infrastructure can come from a more accessible energy system, as well as better possibilities for savings, entrepreneurism and new agricultural activities. The impact of energy generation is not purely related to income increment. It could also significantly improve education, health, and gender equality, considering that improving

electricity access usually has a larger effect on female employment (COOK, 2011). Considering the environmental and social risks involved with new hydropower projects (DÁVALOS; RODRIGUES FILHO; LITRE, 2021; FERREIRA *et al*., 2014), the development of technologies and programs that support the propagation of the use of biomass residues for energy production can play an important role on future sustainable development in Brazil.

Taking a step back to consider `why does it matter' for Minas Gerais to be self-sustainable with biomass residual energy highlights that this importance relies on the historical and economic relevance of the state. A highly populated state can fulfil part of its energy demand with an available resource without requiring land use change or competition with other established markets. This is an important finding concerning the energy matrix change. It means that if it works there, it could also work in other states or regions. This could lead to local arrangements (between states, municipalities or even small communities), depending on their potentials and affinities, in order to promote biomass energy. This could provide a promising new path for the state of Minas Gerais and other parts of the country. A cooperative production system among rural producers is also an alternative to reduce production costs and may allow the partial improvement of agricultural raw materials, adding value to the final product.

Among the production means existing in the state, family farming is the main responsible for the food supply for the state population. Characterised by small properties managed essentially by the family, it presents a larger amount of properties (79% of the farms in the state (IBGE, 2017b)), with greater work and income generation per cultivated area (ABRAMOVAY, 1997). Those small farmers are commonly organised in cooperatives production systems and associations to increase their product's competitiveness and market insertion (COSTA *et al*., 2015). As previously mentioned, since these farmers are already employing this model for other objectives, organising biomass energy production cooperatives using their crop residues could enhance the efficiency of logistics for residue collection and processing, along with the distribution of the generated energy.

One concept that could be applied to developing energy production through biomass residues is the so-called Social Technology. According to (DAGNINO, 2014), a Social Technology is any method, process, product, or technique shaped to solve some social problem that meets the necessities of simplicity, low cost, easy applicability, replicability and proven social impact. An exemplary instance in Brazil is the P1MC program (One Million Rural Cisterns Program), which involved the construction of cisterns as a proactive water policy in the Brazilian semiarid region (ANDRADE; CORDEIRO NETO, 2016). Creating a model for energy production that works for lower income communities and is simple to replicate with minor adaptations could improve the local and regional development without impacting the environment and improving the local economy, as demonstrated by Shukla (2022).

Recent studies, including Casau *et al*. (2022) and Nunes *et al*. (2023), examine the significance of energy generation from biomass waste in effectively realising the foundational principles of a circular and sustainable economy. With an emphasis on agroforestry residues, these studies contribute to the research results by highlighting potential possibilities and making progress in identifying gaps within the energy generation supply chain.

It is important to note that this paper does not address calculations pertaining to collection logistics, material transportation, procurement, power unit installation and operation, or training. Applying this methodology to a sample area, Pimenta and Dalmolin (2021) highlighted that not only financial factors and land availability could impede the implementation of such an enterprise but also the willingness of the local population. While the results of this study were presented, they did not align with the community's preferences for their future development. A more comprehensive investigation should involve the local populace, specifically focusing on biomass energy and its potential applications. Such an approach might yield valuable insights to advance the continuation of this research area in Brazil.

6 CONCLUSIONS

This paper aimed to explore the alternatives for renewable energy generation in Brazil, investigating specifically the case of residual biomass from agriculture and silviculture. The chosen study area was the state of Minas Gerais; a region pointed out by previous research as promising for this type of assessment. A Sustainable Technical Coefficient was developed, taking into consideration that part of the residues would be left on the soil to maintain nutrient cycling and soil health, ensuring sustainability in the long term. The technology chosen for the calculations has low efficiency in energy conversion. Being a cheaper option, easily found in the national market, it was selected as the most viable. The energy demand was estimated and compared with the energy potential results.

In a country where hydro energy represents not only the highest share of the energy matrix but also a fragile energy source, the results of this study reveal a promising new path. For the state of Minas Gerais, with its tradition of agriculture, 78% of the municipalities could meet their basic energy needs through crop residues and silviculture production. When more elaborated uses are considered, there is a drop where 18% of the municipalities could be self-sufficient in energy supply. Even with a significant reduction in the percentage, this would relieve pressures placed on the construction of new hydroelectric plants, which have substantial negative impacts on the environment and the way of life of the communities in the surroundings of the flooded areas. A cooperative production system among rural producers is also presented as an alternative to reduce production costs and may allow the partial improvement of agricultural raw material, adding value to the final product. An energy mix where other renewable energy sources are considered can also increase the chances of success of an enterprise focused on renewable energy.

Since 2015, Brazil has faced an economic downturn that tends to decrease the attractiveness of an investment. Other relevant aspects for consideration are the lack of policies that encourage the deployment of new renewable energies and the questionable environmental agenda adopted by the government from 2018-2022. The results obtained here can be used to empower the local population or stakeholders to seek renewable energy projects, creating the ground for changes in the country's energy system.

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REFERENCES

ABDEL DAIEM, M. M.; SAID, N. Energetic, economic, and environmental perspectives of power generation from residual biomass in Saudi Arabia. **Alexandria Engineering Journal**, v. 61, n. 5, p. 3351–3364, 1 may 2022.

ABRAMOVAY, R. Agricultura familiar e uso do solo. **Revista São Paulo em perspectiva**, v. 11, n. 2, p. 73–78, 1997.

ABRAMOVAY, R. Innovations to democratise energy access without boosting emissions. **Ambiente & Sociedade**, v. 17, n. 3, p. 01–18, set. 2014.

ALMEIDA, E. L. F. DE.; PINTO JÚNIOR, H. Q. Driving forces of the Brazilian electricity industry reform. **Energy Studies Review**, v. 9, n. 2, 2000.

ANDRADE, J. A. DE.; CORDEIRO NETO, J. R. Uma discussão sobre a possibilidade da criação institucional e sinergia entre Estado e sociedade: o caso do P1MC no semiárido brasileiro. **Cadernos EBAPE.BR**, v. 14, n. spe, p. 551–568, july 2016.

BASTOS, S. Q. DE A.; GOMES, J. E. Dinâmica da Agricultura no Estado de Minas Gerais: análise estrutural-diferencial para o período 1994-2008. **Ruris**, v. 5, n. 2, 2011.

BATIDZIRAI, B. *et al*. **Current and future technical, economic and environmental feasibility of maise and wheat residues supply for biomass energy application**: illustrated for South Africa. 2016.

BHATTACHARYYA, S. C. Viability of off-grid electricity supply using rice husk: a case study from South Asia. **Biomass and Bioenergy**, v. 68, p. 44–54, sept. 2014.

BLASCHKE, T. *et al*. Energy landscapes: meeting energy demands and human aspirations. **Biomass and Bioenergy**, v. 55, p. 3–16, 2013a.

BLASCHKE, T. *et al*. Energy landscapes: meeting energy demands and human aspirations. **Biomass and Bioenergy**, v. 55, p. 3–16, aug. 2013b.

BUSARI, M. A. *et al*. Conservation tillage impacts on soil, crop and the environment. **International Soil and Water Conservation Research**, v. 3, p. 119–129, 2018.

CALIXTO, J. S. *et al*. Labor, land and income generation in three decades of reforestation in the Upper Jequitinhonha Valley. **Revista de Economia e Sociologia Rural**, v. 47, n. 2, p. 519–538, june 2009.

CARVALHO, L. M. T. *et al*. Flora. In: **Zoneamento Ecológico-Econômico do estado de Minas Gerais**: componentes geofísico e biótico. p. 137–150. 2008.

CASAU, M. *et al*. Residual Biomass: a comprehensive review on the importance, uses and potential in a circular bioeconomy approach. **Resources 2022**, v. 11, n. 4, p. 35, 30 mar. 2022.

CEMIG. **Cemig electric energy**. Available at: http://www.cemig.com.br/en-us/the_cemig/our_business/energy/Pages/default.aspx. Accessed on: 14 nov. 2018.

COELHO, S. T. *et al*. Biomass Residues as Electricity Generation Source in Low HDI Regions of Brazil. XI LATIN-AMERICAN CONGRESS ON ELECTRICITY GENERATION AND TRANSMISSION - CLAGTEE 2015. **Anais** [...] 2015.

COELHO, S. T.; GOLDEMBERG, J. Energy access: lessons learned in Brazil and perspectives for replication in other developing countries. **Energy Policy**, v. 61, p. 1088–1096, 2013.

COELHO, S. T.; MONTEIRO, M. B.; KARNIOL, M. DA R. **Atlas de Bioenergia do Brasil**. São Paulo: 2012.

COOK, P. Infrastructure, rural electrification and development. **Energy for Sustainable Development**, v. 15, n. 3, p. 304–313, sept. 2011.

COSTA, B. A. L. *et al*. As Cooperativas de Agricultura Familiar e o Mercado de Compras Governamentais em Minas Gerais. **Revista de Economia e Sociologia Rural**, v. 53, n. 1, p. 109–126, mar. 2015.

DAGNINO, R. **Tecnologia Social**: contribuições conceituais e metodológicas. [s.l.] EDUEPB, 2014.

DÁVALOS, N. B.; RODRIGUES FILHO, S.; LITRE, G. The impacts of the construction of hydroelectrics on indigenous communities. Displacement, division and pilgrimage among The Tuxá peoples of Bahia state, Brazil. **Sustainability in Debate**, v. 12, n. 1, p. 220–235, 7 may 2021.

DIAS, J. M. C. DE S. *et al*. **Produção de briquetes e péletes a partir de resíduos agrícolas, agroindustriais e florestais**. Brasília - DF: Embrapa Agroenergia, 2012.

DÍAZ-CUEVAS, P.; DOMÍNGUEZ-BRAVO, J.; PRIETO-CAMPOS, A. Integrating MCDM and GIS for renewable energy spatial models: assessing the individual and combined potential for wind, solar and biomass energy in Southern Spain. **Clean Technologies and Environmental Policy**, p. 1–15, 28 aug. 2019.

EPE. **Inventário Energético de Resíduos Rurais**. Rio de Janeiro: 2014.

EPE. *Brazilian Energy Balance 2022/Year 2021*. Rio de Janeiro. Available at: http://www.epe.gov.br. Accessed on: 7 aug. 2023.

FEARNSIDE, P. M. As hidrelétricas de Belo Monte e Altamira (Babaquara) como fontes de gases de efeito estufa. **Novos Cadernos Naea**, v. 12, n. 2, p. 5–56, 2009.

FEARNSIDE, P. M.; PUEYO, S. Greenhouse-gas emissions from tropical dams. **Nature Climate Change**, v. 2, n. 6, p. 382–384, 2012.

FERREIRA, J. *et al*. Brazil's environmental leadership at risk. **Science**, v. 346, n. 6210, p. 706–707, 6 nov. 2014.

FJP. **MINAS E-DADOS 2018**. Belo Horizonte: 2018.

FOELKEL, C. Utilização da Biomassa do Eucalipto para Produção de Calor, Vapor e Eletricidade - Parte 3: Resíduos Florestais Energéticos. In: **Eucalyptus Online Book**, Cap. 45. 2016.

FUCHS, V. B. Blaming the Weather, Blaming the People: socio-environmental governance and a crisis attitude in the Brazilian electricity sector. **Ambiente & Sociedade**, v. 19, n. 2, p. 221–246, 2016.

GBIO *et al*. **Biomass Residues as Energy Source to Improve Energy Access and Local Economic Activity in Low HDI Regions of Brazil and Colombia (Brea)**. São Paulo: 2015.

GOMES, A. C. S. *et al*. **Histórias Setoriais**: o setor elétrico. 2002.

GOMES, K. **Para evitar crise, Brasil precisa diversificar matriz energética**. Available at: http://goo.gl/3bqdUf. Accessed on: 18 aug. 2014.

HAAREN, C. VON *et al*. Erneuerbare Energien – Zielkonflikte zwischen Natur – und Umweltschutz. **Deutscher Naturschutztag**, v. 31, p. 17–31, 2012.

HOBBS, P. R.; SAYRE, K.; GUPTA, R. The role of conservation agriculture in sustainable agriculture. Philosophical transactions of the Royal Society of London. Series B. **Biological sciences**, v. 363, n. 1491, p. 543–55, 12 feb. 2008.

IBGE. **Censo Agropecuário 2006 - Agricultura Familiar**. Rio de Janeiro: 2009.

IBGE. **Brasil em Síntese**: Minas Gerais. Available at: https://cidades.ibge.gov.br/brasil/mg/panorama. Accessed on: 6 june 2018a.

IBGE. **Censo Agro 2017**: Resultados. Available at: https://censos.ibge.gov.br/agro/2017/resultados-censo-agro-2017.html. Accessed on: 16 nov. 2018b.

IBGE. **Cidades**: Minas Gerais. Panorama. Available at: https://cidades.ibge.gov.br/brasil/mg/panorama. Accessed on: 26 sept. 2019.

IBGE. **Censo Demográfico 2022 - População e domicílios**. Primeiros resultados. Rio de Janeiro: [s.n.]. Available at: https://biblioteca.ibge.gov.br/visualizacao/livros/liv102011.pdf. Accessed on: 7 aug. 2023.

LILLO, P. *et al*. Assessing management models for off-grid renewable energy electrification projects using the Human Development approach: case study in Peru. **Energy for Sustainable Development**, v. 25, p. 17–26, apr. 2015.

LORENZO, H. C. DE. The brazilian electrical sector: past and future. **Perspectivas**, v. 24–25, p. 147–170, 2002.

MAPA. **Exportações do agronegócio fecham 2022 com US$ 159 bilhões em vendas**. Available at: https://www.gov.br/agricultura/pt-br/assuntos/noticias/exportacoes-do-agronegocio-fecham-2022-com-us-159-bilhoes-em-vendas. Accessed on: 8 aug. 2023.

MORAN, E. F. *et al*. Sustainable hydropower in the 21st century. **Proceedings of the National Academy of Sciences of the United States of America**, p. 201809426, 5 nov. 2018.

NUNES, L. J. R. *et al*. Agroforest woody residual biomass-to-energy supply chain analysis: feasible and sustainable renewable resource exploitation for an alternative to fossil fuels. **Results in Engineering**, v. 17, p. 101010, 1 mar. 2023.

OLIVEIRA, S. N. DE *et al*. Landscape-fragmentation change due to recent agricultural expansion in the Brazilian Savanna, Western Bahia, Brazil. **Regional Environmental Change**, v. 17, n. 2, p. 411–423, 23 feb. 2017.

PALMAS, C. *et al*. Renewables in residential development: an integrated GIS-based multi-criteria approach for decentralised micro-renewable energy production in new settlement development: a case study of the eastern metropolitan area of Cagliari, Sardinia, Italy. **Energy, Sustainability and Society**, v. 2, n. 1, p. 10, 2012.

PALMAS, C.; SIEWERT, A.; VON HAAREN, C. Exploring the decision-space for renewable energy generation to enhance spatial efficiency. **Environmental Impact Assessment Review**, v. 52, p. 9, aug. 2015.

RIBEIRO, A. P.; DALMOLIN, S. Biomass energy as a possibility for innovative agriculture initiatives. **Energy, Ecology and Environment**, v. 6, n. 4, p. 344–352, 1o. aug. 2021.

RIBEIRO, A. P.; RODE, M. Spatialised potential for biomass energy production in Brazil: an overview. **Brazilian Journal of Science and Technology**, v. 3, n. 1, p. 13, 17 sept. 2016.

RIBEIRO, A. P.; RODE, M. Residual biomass energy potential: perspectives in a peripheral region in Brazil. **Clean Technologies and Environmental Policy**, v. 21, n. 4, p. 733–744, 2019.

SEAPA. **Exportações do agronegócio mineiro alcançam US$ 15,3 bilhões em 2022 e atingem novo recorde**. Available at: https://www.mg.gov.br/agricultura/noticias/exportacoes-do-agronegocio-mineiro-alcancam-us-153-bilhoes-em-2022-e-atingem. Accessed on: 8 aug. 2023.

SHAPIRO-BENGTSEN, S. *et al*. Should residual biomass be used for fuels, power and heat, or materials? Assessing costs and environmental impacts for China in 2035. **Energy & Environmental Science**, v. 15, n. 5, p. 1950–1966, 18 may 2022.

SHUKLA, I. Potential of renewable agricultural wastes in the smart and sustainable steelmaking process. **Journal of Cleaner Production**, v. 370, p. 133422, 10 oct. 2022.

SIDRA; IBGE. **Produção Agrícola Municipal**. Available at: https://sidra.ibge.gov.br/pesquisa/pam/tabelas. Accessed on: 15 oct. 2016a.

SIDRA; IBGE. **Produção da Extração Vegetal e da Silvicultura**. Available at: https://sidra.ibge.gov.br/pesquisa/pevs/quadros/brasil/2015. Accessed on: 15 oct. 2016b.

SKOULOU, V. *et al*. Sustainable management of energy crops for integrated biofuels and green energy production in Greece. **Renewable and Sustainable Energy Reviews**, v. 15, n. 4, p. 1928–1936, may 2011.

SÖDERBERG, C.; ECKERBERG, K. Rising policy conflicts in Europe over bioenergy and forestry. **Forest Policy and Economics**, v. 33, p. 112–119, aug. 2013.

SOMMER, R. *et al*. Reducing losses but failing to sequester carbon in soils – the case of Conservation Agriculture and Integrated Soil Fertility Management in the humid tropical agro-ecosystem of Western Kenya. **Agriculture, Ecosystems & Environment**, v. 254, p. 82–91, 15 feb. 2018.

SOUZA, R. L. DE. **Identidades regionais**: São Paulo, Minas Gerais, Rio Grande do Sul, Bahia – Ricardo Luiz de Souza - Google Livros. Londrina, PR: Eduel, 2013.

TOVAR, B.; RAMOS-REAL, F. J.; ALMEIDA, E. F. DE. Firm size and productivity. Evidence from the electricity distribution industry in Brazil. **Energy Policy**, v. 39, p. 826–833, 2010.

VEDOVATO, L. B. *et al*. The extent of 2014 forest fragmentation in the Brazilian Amazon. R**egional Environmental Change**, v. 16, n. 8, p. 2485–2490, 25 dec. 2016.

VENGHAUS, S.; ACOSTA, L. To produce or not to produce: an analysis of bioenergy and crop production decisions based on farmer typologies in Brandenburg, Germany. **Regional Environmental Change**, v. 18, n. 2, p. 521–532, 2 feb. 2018.

VIDAL, A. C. F.; HORA, A. B. DA. Perspectivas do setor de biomassa de madeira para a geração de energia. **Papel e Celulose**, n. 33, p. 261–314, 2011.

WELFLE, A. Balancing growing global bioenergy resource demands – Brazil's biomass potential and the availability of resource for trade. **Biomass and Bioenergy**, v. 105, p. 83–95, oct. 2017.

WINEMILLER, K. O. *et al*. Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. **Science**, v. 351, n. 6.269, p. 128–129, 2016.

Driving factors for the installation of mini and micro rural distributed generation systems: economic analysis – a case study in *Piauí*, Brazil

Fatores impulsionadores para a mini e microgeração distribuída rural: análise econômica – um estudo de caso no Piauí, Brasil

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ABSTRACT

The agricultural sector has a low representation in the Brazilian energy mix and in terms of distributed generation systems installed in rural areas. However, this sector represents a large portion of the gross domestic product. This work proposes an approach for identifying the driving factors for inserting mini and micro distributed generation systems in the agricultural sector. A methodology was developed based on a territorial approach, using indicators in Piauí to determine the major factors that drive its

installation. It is observed that the main driving factor for rural microsystems is the total irrigated area of agricultural establishments. As for mini rural systems, the main driving factor is the average area of agricultural enterprises. In addition, it is reasonable to state that the proposed methodology applies to other states, from a regional and national perspective, as well as to other types of consumers.

Keywords: Farming. Photovoltaic Systems. Countryside areas.

RESUMO

O setor agropecuário tem baixa representatividade na matriz energética brasileira e nos sistemas de geração distribuída instalados no meio rural. No entanto, esse setor representa uma grande parcela do produto interno bruto. Este trabalho propõe uma abordagem para identificar os fatores determinantes para a inserção de mini e microssistemas de geração distribuída no setor agrícola, por meio de um enfoque territorial, usando indicadores do Piauí para determinar os principais fatores que impulsionam sua instalação. Observa-se que o principal fator impulsionador dos microssistemas rurais é a área total irrigada dos estabelecimentos agropecuários, enquanto que, com relação aos minissistemas rurais, o principal fator impulsionador é a área média dos empreendimentos agrícolas. Além disso, é razoável afirmar que a metodologia proposta se mostra aplicável a outros estados, do ponto de vista regional e nacional, bem como a outros tipos de consumidores.

Palavras-chave: Agricultura. Sistemas Fotovoltaicos. Áreas rurais.

1 INTRODUCTION

In September 2015, member countries of the United Nations (UN), including Brazil, committed to Agenda 2030, a global cooperation agreement composed of 17 Sustainable Development Goals (SDGs) and 169 targets to be pursued over the next 15 years. Since its publication, among other contributions, the 2030 Agenda has stimulated research development in quantitative and qualitative terms, considering that energy is one of the most prominent themes (GARLET *et al*., 2022). In this context, the aim is to promote universal access to electric energy, increase the share of renewable energies, double the global energy efficiency rate, and strengthen international cooperation in research and technology transfer (UN, 2015).

Universal access to electricity is relevant to sustainable development, but it has not yet been consolidated. According to the World Bank, the number of people without access to electricity worldwide decreased from 1.2 billion in 2010 to 733 million in 2022. However, in 2030, it is estimated that 670 million people will remain without access to electricity. It corresponds to an increase of 10 million compared with the projection presented in 2021, resulting in a significant impact on health, productivity, and life quality (WORLD BANK, 2023). This aspect is a major challenge for underdeveloped countries, where complex energy solutions are required due to geographic, social, and environmental issues, especially in rural regions (LEDUCHOWICZ-MUNICIO *et al*., 2022). In Brazil, 99.5% of the population has access to electricity, which corresponds to a better scenario when compared with other essential public services such as water supply (85.5%), sewage (68.3%), and garbage collection (84.4%) (LAMIN, 2021).

Population growth and economic development increase the electricity demand, which must be met by increasing energy efficiency indices and building new generating plants, but the latter often causes significant socio-environmental impacts. In Brazil, the percentage of renewable energy sources in the energy matrix corresponding to 44.7% in 2021 represents more than three times that of the world matrix in 2019, 14.1%. However, this portion can still be significantly increased (EPE, 2022). Once the use of renewable energies generates few socio-environmental impacts and such resources are virtually infinite (MENDES *et al*., 2022), their promotion should be encouraged in world economies. In this scenario, they will reduce both greenhouse gas emissions and transmission losses, given that the plants are closer to consumer centres, with the possibility of reducing the share of thermal power plants.

Although power generation based on renewable energies is an alternative for sustainable development, its entire life cycle must be considered to assess socio-environmental impacts properly. The implementation process must consider the extraction and treatment of materials, equipment production, and the installation and implementation of facilities. Other important issues include operation, maintenance, equipment decommissioning, and disposal (MOTUZIENĖ *et al*., 2022).

The Brazilian matrix has a large insertion of hydroelectric generation, a renewable source. However, it causes great socio-environmental impacts in its implementation process (MENDES *et al*., 2022). In this way, other renewable energy sources have been gaining prominence in the Brazilian and global matrices, such as wind and solar, whose participation increased in absolute and relative terms in the Brazilian matrix from 2020 to 2021, respectively. In 2021, 570.8 TWh was consumed in Brazil, whereas the agricultural sector is responsible for 33.9 TWh (5.0%), corresponding to an increase of 1.4 TWh (4.2%) compared with the previous year (EPE, 2022).

According to the last agricultural census carried out in Brazil, the participation of agriculture in the Brazilian gross domestic product (GDP) increased by 8.36% in 2021 and reached a total of 27.4%. This is the highest amount reported since 2004, corresponding to 27.53%. In this sense, it is evident that this sector has an important role in inducing national economic development and in its foreign policy (AZEVEDO JÚNIOR; SANTANA, 2022; CEPEA, 2022), being responsible for 5.0% of the overall energy consumption in Brazil (EPE, 2022). For instance, in the state of Piauí, this activity uses an area of 10 million hectares (2.8% of all occupied Brazilian territory), being responsible for the direct occupation of 670 thousand people, that is 4.4% of all Brazilians directly involved with such activity (IBGE, 2019). It is worth mentioning that the agricultural census in Brazil occurs every 10 years, as promoted by the Brazilian Institute of Geography and Statistics (IBGE), thus being an important tool for decision-making (MORAIS *et al*., 2020).

Sustainable development can be considered as a set of processes and actions that must be considered from a global perspective and executed at national, regional, and local levels, thus allowing the entire planet to develop equally (BOFF, 2017). Ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture consist of one of the Sustainable Development Goals, SDG 2. The latter aims to develop technology and increase investments in rural infrastructure, agricultural research, and extension services to enhance agricultural productive capacity in developing countries, particularly in least-developed countries (UN, 2015). Within this scenario, family farming stands out in Brazil, accounting for 67% of all agriculture workers and 77% of agricultural establishments. It plays a key role in the production of cassava, coffee, bananas, and beans, representing 80%, 48%, 48%, and 42% of the total amount, respectively, also considering that such products are of great relevance to the population's diet (IBGE, 2019).

Even so, the participation of family farming in Brazil has been decreasing. In this sense, the application of renewable energy sources in the activities mentioned above has the potential to increase the autonomy of all involved families, in addition to improving the social technologies that already exist in Brazilian rural communities (BORGES; LUNA, 2017; GONZÁLEZ *et al*., 2022). As an attempt to contribute to 2030 Agenda goals, especially regarding the increased participation of renewable energy in rural areas, this article aims to develop a methodology for identifying the factors that drive the insertion of mini and micro distributed generation (DG) systems in the agricultural sector, taking the state of *Piauí* as the object of study. Although the present study has a local nature, one can apply the introduced methodology in other territories and subsidise sustainable development at a global level. The research can significantly contribute to inserting DG in the agricultural sector, which is responsible for more than a quarter of the Brazilian GDP, and promoting family farming.

2 METHODOLOGICAL PROCEDURES

The state of *Piauí* is divided into 12 development territories (DTs) (Figure 1) with different potentialities, among which agriculture stands out (MORAIS *et al*., 2020). Regarding the number of municipalities and area, the largest territories in the state are *Entre Rios*, with 31 municipalities, and *Chapada das Mangabeiras*, with 54,044.7 km².

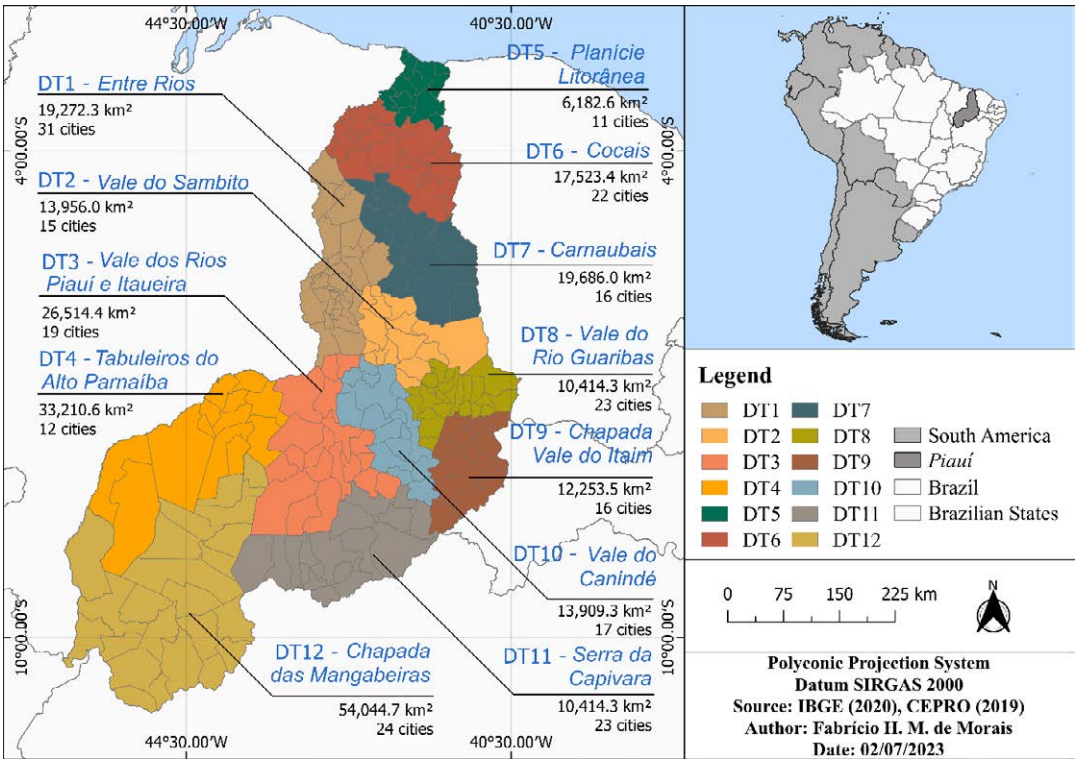

Figure 1 | Piauí's development territories

Source: Cepro (2019).

Thus, initially, the environmental and socioeconomic characterisation of the territories was performed from the analysis of the Human Development Index (HDI) from municipalities, obtained from the United Nations Development Programme – UNDP (PNUD, 2023) which were handled using spreadsheets and geographic information software (MICROSOFT, 2021; OSGEO, 2023). Notably, Freitas *et al*. (2021) also used this territorial approach which evaluated the productive interaction capacity of people from *Piauí* based on the spatiality of patent production by public research institutions. This approach is also suggested by Morais *et al*. (2020) specifically for family farming studies in *Piauí* since it can be understood as a key activity in the local economy.

The human development concept and related measurement indicators were presented in 1990 in the first Human Development Report of the UNDP and became a popular measure of the human development level of a country. The HDI comprises three other indicators: life expectancy or longevity, which evaluates the opportunity to have a long and healthy life; education, which measures access to knowledge; and income, which measures access to decent living standards.

Furthermore, these indices have been adapted locally to countries such as Argentina, China, India, South Africa, and Brazil. Under the responsibility of the Brazilian Institute for Economic and Applied Research (Ipea) and the João Pinheiro Foundation, a methodology was developed to assess the human development of Brazilian municipalities through the HDI. It takes into account longevity, education, and income, thus serving as a reference for several studies that evaluate such issues from a subnational

perspective (DINIZ *et al*., 2021; PNUD, 2023; PROCÓPIO *et al*., 2020). The closer the HDI is to unity, the greater the human development. However, one can adopt intervals to characterise human development as very low (HDI<0.5); low (0.5≤HDI<0.6); medium (0.6≤HDI<0.7); high (0.7≤HDI<0.8); and very high (HDI≥0.8) (DINIZ *et al*., 2021; PNUD, 2023; PROCÓPIO *et al*., 2020).

This index can direct actions to improve these environmental aspects, both from an integral perspective and concerning its secondary levels, and access to electricity can be seen as an infrastructure issue that can promote citizenship (FREITAS, 2022). Nevertheless, especially in rural areas, universal access is a challenge (LEDUCHOWICZ-MUNICIO *et al*., 2022). Thus, to its characterisation, using data from IBGE (2019), also treated by spreadsheet programs (MICROSOFT, 2021), the number of agricultural establishments which do not have access to this asset was determined, considering only those establishments where the use of electricity is desirable.

This research used the Pearson correlation coefficient (PCC) to determine the strength of linear association between two variables. Thus, the indicators are strongly correlated if the PCC is greater than 0.8 (SILVA; CASTRO, 2022). However, they are moderately correlated if it is between 0.5 and 0.8. The variables are weakly correlated if the PCC is lower than 0.5 (SILVA *et al*., 2022). Thus, using open data obtained from the Brazilian National Electric Energy Agency – Aneel (ANEEL, 2023), which were treated by spreadsheet, business intelligence and Geographic Information programs (MICROSOFT, 2021, 2022; OSGEO, 2023), one can determine the number of facilities and the installed power of mini and micro DG systems in rural areas for each of the territories. The total power of the rural systems in Piauí was correlated with the total power of residential, commercial, and industrial systems in the state using the PCC to determine the similarity level of the distributions (ANEEL, 2023).

Table 1 presents the average human development in *Piauí*'s territories obtained from Pnud (2023). The data are summarised in spreadsheets using business intelligence software (MICROSOFT, 2021, 2022). The main indicators include environmental and socioeconomic issues, in addition to aspects related to DG and agriculture in all municipalities (ANEEL, 2023; IBGE, 2019; PEREIRA *et al*., 2017; PNUD, 2023). The same data and tools were also used to evaluate the most correlated factors with the state's distribution of rural mini-generation and microgeneration systems, defined as driving factors for their installations. Using the PCC, the indicators of mini and micro DG rural systems were first correlated with the other types of DG systems in *Piauí* and later correlated with the environmental, socioeconomic, and farming indicators. Scatter plots were obtained to illustrate the study aiming to show the equations that describe the variation of indicators and the R^2 coefficient that determines the model suitability.

Table 1 | Matrix of indicators for identifying the driving factors of rural DG systems

U#	*Environmental Aspect*	*Environmental Indicator*
Ind.1	DG	Total rated power of micro DG systems
Ind.2	DG	Rated power of micro DG residential systems
Ind.3	DG	Rated power of micro DG commercial systems
Ind.4	DG	Rated power of micro DG industrial systems
Ind.5	DG	Total rated power of mini DG systems
Ind.6	DG	Rated power of mini DG residential systems
Ind.7	DG	Rated power of mini DG commercial systems
Ind.8	DG	Rated power of mini DG industrial systems
Ind.9	Environmental	Total area of municipalities (km^2)
Ind.10	Environmental	Average annual global horizontal irradiation
Ind.11	Socioeconomic	HDI
Ind.12	Socioeconomic	Income
Ind.13	Socioeconomic	Education

U#	Environmental Aspect	Environmental Indicator
Ind.14	Socioeconomic	Longevity
Ind.15	Socioeconomic	Number of agricultural establishments with access to electricity
Ind.16	Farming	Total area of agricultural establishments
Ind.17	Farming	Average area of agricultural establishments
Ind.18	Farming	Average area of agricultural establishments involved with family farming
Ind.19	Farming	Total area of agricultural establishments with access to irrigation
Ind.20	Farming	Total agroindustry production
Ind.21	Farming	Number of agricultural establishments with access to funding
Ind.22	Farming	Number of agricultural establishments associated with funding programs
Ind.23	Farming	Number of agricultural establishments whose owner lives on the property
Ind.24	Farming	Number of agricultural establishments whose producer is the owner

Source: Aneel (2023), IBGE (2019), Pereira et al. (2017) and Pnud (2023).

3 RESULTS AND DISCUSSION

The average HDI of the 224 municipalities in *Piauí* is 0.541, a low value (PNUD, 2023) (Table 2). A total of 78.6% have a low HDI, among which 2.7% and 17.9% correspond to municipalities with very low and medium development levels, respectively. Only two municipalities (0.9%) present a high HDI. It is also noteworthy that the *Entre Rios* territory, which comprises *Piaui*'s capital, *Teresina*, has the highest average HDI, 0.751. *Planície Litorânea* territory has the lowest average HDI in the state (0.541), whereas *Vale do Canindé* territory has the lowest HDI (0.485).

Table 2 | Average HDI of Piauí's development territories

TD	HDI	Education	Longevity	Income
TD1	0.595	0.496	0.562	0.760
TD2	0.584	0.480	0.552	0.755
TD3	0.562	0.446	0.539	0.741
TD4	0.596	0.489	0.569	0.763
TD5	0.541	0.401	0.531	0.750
TD6	0.553	0.424	0.530	0.756
TD7	0.571	0.456	0.539	0.761
TD8	0.572	0.452	0.562	0.739
TD9	0.545	0.420	0.535	0.722
TD10	0.574	0.466	0.551	0.741
TD11	0.564	0.454	0.531	0.748
TD12	0.576	0.463	0.548	0.756
Piauí	**0.569**	**0.454**	**0.546**	**0.749**

Source: Pnud (2023).

Improving human development in all development territories of *Piauí* is a challenge. In this sense, the HDI can direct actions to improve these environmental aspects, both from an integral perspective and concerning its secondary levels, that is, longevity, education, and income. Access to electricity can be seen as an infrastructure issue that can promote citizenship (FREITAS, 2022), but universal access is also a challenge in *Piauí*, especially in rural areas (LEDUCHOWICZ-MUNICIO *et al*., 2022). Among 244,206 agricultural establishments where electricity is desirable, 18.54% do not have access to this asset.

In this context, *Entre Rios* and *Chapada das Mangabeiras* represent the territories with the largest number of establishments without access to electricity in absolute (7674 establishments) and relative (32.00%) terms, according to Figure 2.

The use of renewable energies in such activities can improve autonomy, contributing positively to universal access to electricity, especially in family farming (BORGES; LUNA, 2017; GONZÁLEZ *et al*., 2022; JEAN; BRASIL JUNIOR, 2022). Furthermore, the lack of reliable records in off-grid systems makes a more accurate analysis of rural electrification trends somewhat complex. However, even in agricultural establishments where access to electricity is guaranteed, the legal framework created in 2012 has allowed the installation of distributed mini-generation and microgeneration systems to inject the generated energy into the grid (SILVA *et al*., 2019). However, after a modified Brazilian regulation was established in 2022, the government incentives for this became less attractive (COSTA *et al*., 2022; SOARES; BARRETO, 2022). As the penetration of this type of generation increases, generation and transmission costs decrease, making it a prominent alternative to supply the increasing demand and reduce the use of fossil fuels (ARNAWAN *et al*., 2021; GIMENES *et al*., 2022).

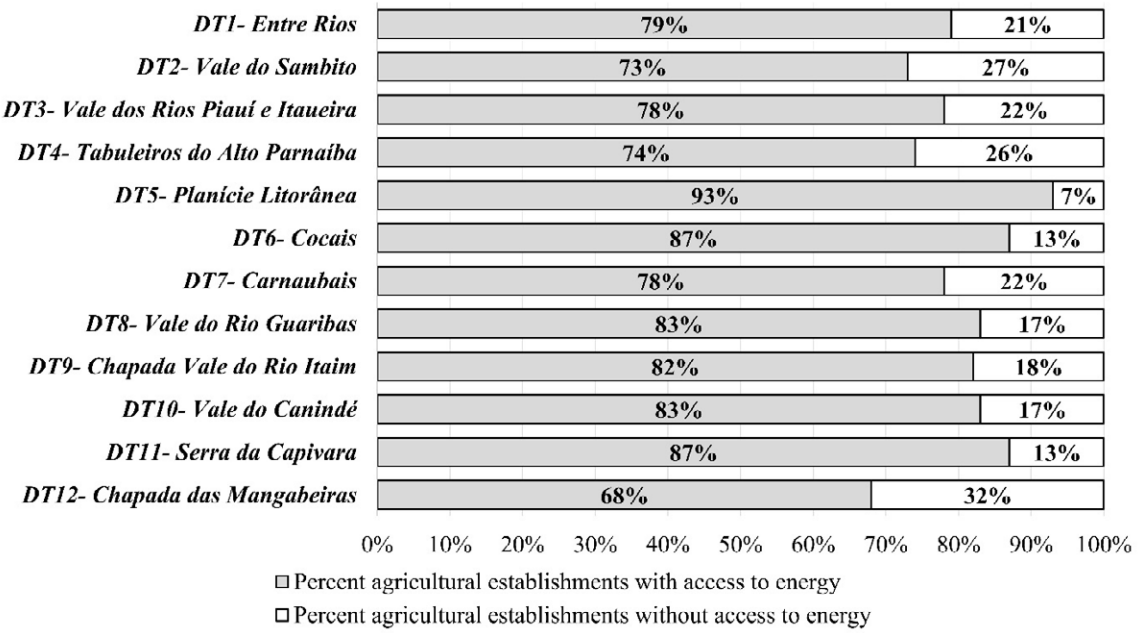

Figure 2 | Access to electricity in agricultural establishments in *Piauí*'s development territories

Source: IBGE (2019).

The Brazilian Northeast region, which comprises the state of *Piauí*, has the country's greatest solar potential for energy generation (ALMEIDA; ALMEIDA, 2022; MEDEIROS *et al*., 2021). *Piauí* is no different, especially in the case of municipalities of the Southeast region (PEREIRA *et al*., 2017; SILVA *et al*., 2021). With a daily average solar irradiance of 5.71 kWh/m², that is, 4% higher than the Brazilian Northeast region's average (PEREIRA *et al*., 2017), all mini and micro DG systems in the state consist of photovoltaic systems. In turn, there is also great potential for establishing wind power plants, especially in the municipalities of *Parnaíba* and *Paulistana*, where large farms are currently installed (LIRA *et al*., 2017). By January 9, 2023, 29,457 DG units had been installed in the state, resulting in a total power of 298,103.76 kWh (Figure 3). 99.54% of the facilities correspond to microgeneration systems, which account for 86.92% of the total installed power. Rural systems represent 1.76% of the existing systems and 3.32% of the installed capacity in *Piauí*. In turn, they account for 8.41% of DG systems and 14.77% of the installed capacity in Brazil (ANEEL, 2023). The *Entre Rios* territory has the highest number of

microgeneration systems and installed power. Similarly, the *Tabuleiros do Alto Parnaíba* territory has the highest number of facilities and installed power in terms of mini-generation systems.

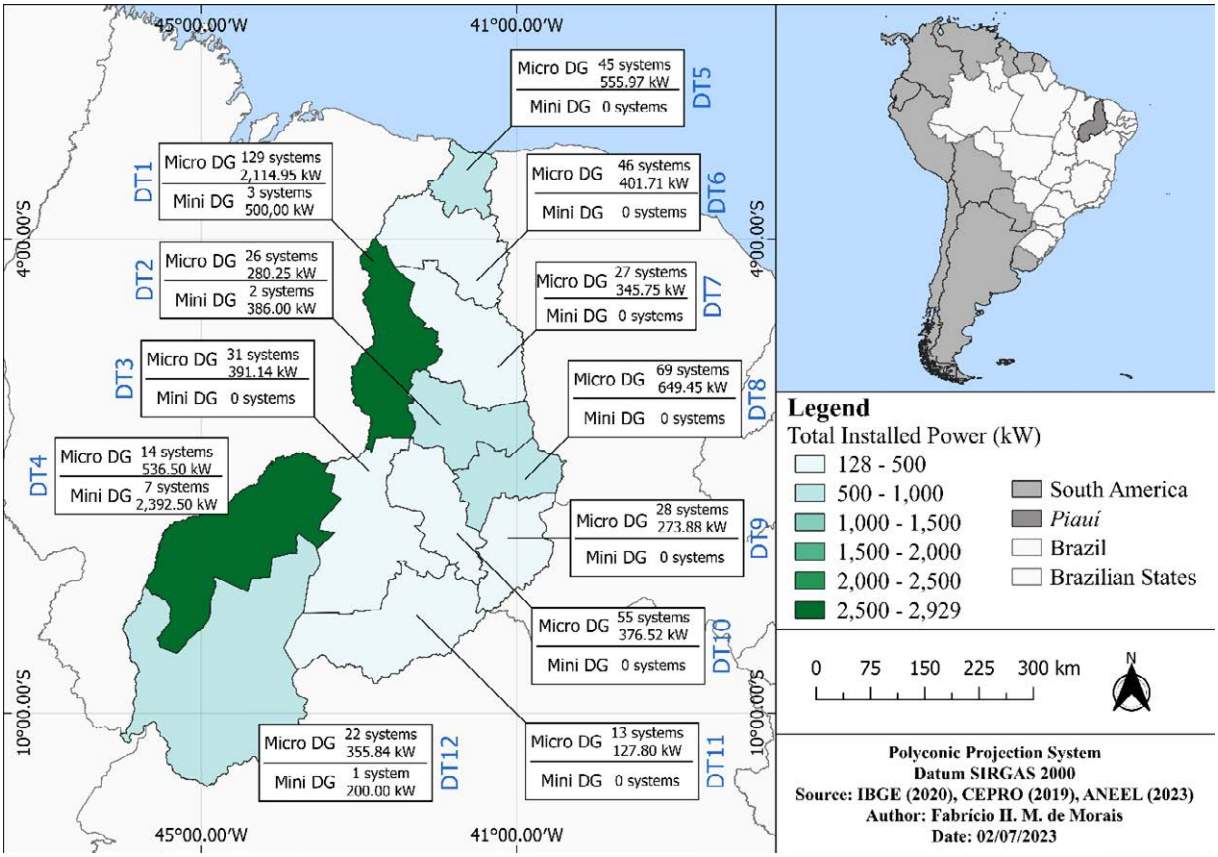

Figure 3 | Rural mini and micro DG systems in Piauí's development territories

Source: Aneel (2023).

The total installed power of rural DG systems in *Piauí* has a moderate correlation when compared with residential, commercial, and industrial systems, corresponding to correlation coefficients of 0.679, 0.678, and 0.661, respectively, thus denoting distinct dynamics for each system (ANEEL, 2023). Figure 4 represents the rural micro DG systems in the state in terms of installed power and the number of existing facilities up to January 9, 2023. Piauí has 505 systems installed in 138 municipalities (61.16%), with an average power of 12.69 kW/system. *Teresina*, which is *Piauí*'s capital and is located in the *Entre Rios* territory, stands out with 72 installed systems (14.26% of the total number of rural microgeneration systems), comprising an installed power of 1201.61 kW (18.75% of the total installed power of rural microgeneration systems) (ANEEL, 2023).

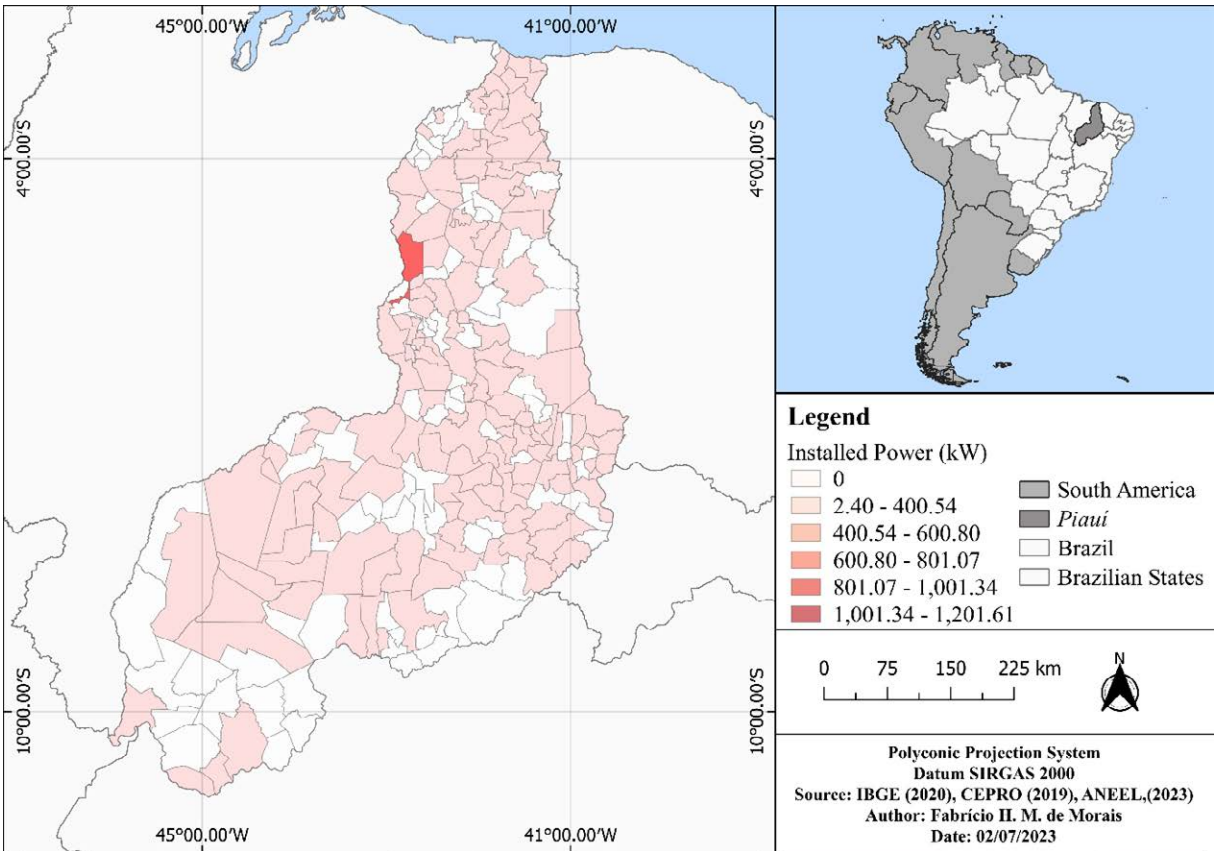

Figure 4 | Rural micro DG systems in Piauí's municipalities

Source: Aneel (2023).

Concerning rural mini DG systems, one could identify only 13 systems with an average power of 267.58 kW/system, 20.1 times greater than the average power of rural micro DG systems. The units are installed in six municipalities as shown in Figure 5: *Baixa Grande do Ribeiro* (three systems with a total of 892.5 kW), *Currais* (one system rated at 200.0 kW), *Sebastião Leal* (three systems with a total of 1380.0 kW), *Teresina* (three systems with a total of 500 kW), *Uruçuí* (one system rated at 120 kW), and *Valença do Piauí* (two systems with a total of 386.0 kW). Therefore, rural micro DG systems exist in only three development territories: *Tabuleiros do Alto Parnaíba* (seven systems with a total of 2,392.50 KW), *Entre Rios* (three systems with a total of 500 kW), and *Chapada das Mangabeiras* (one system rated at 200.0 kW) (ANEEL, 2023).

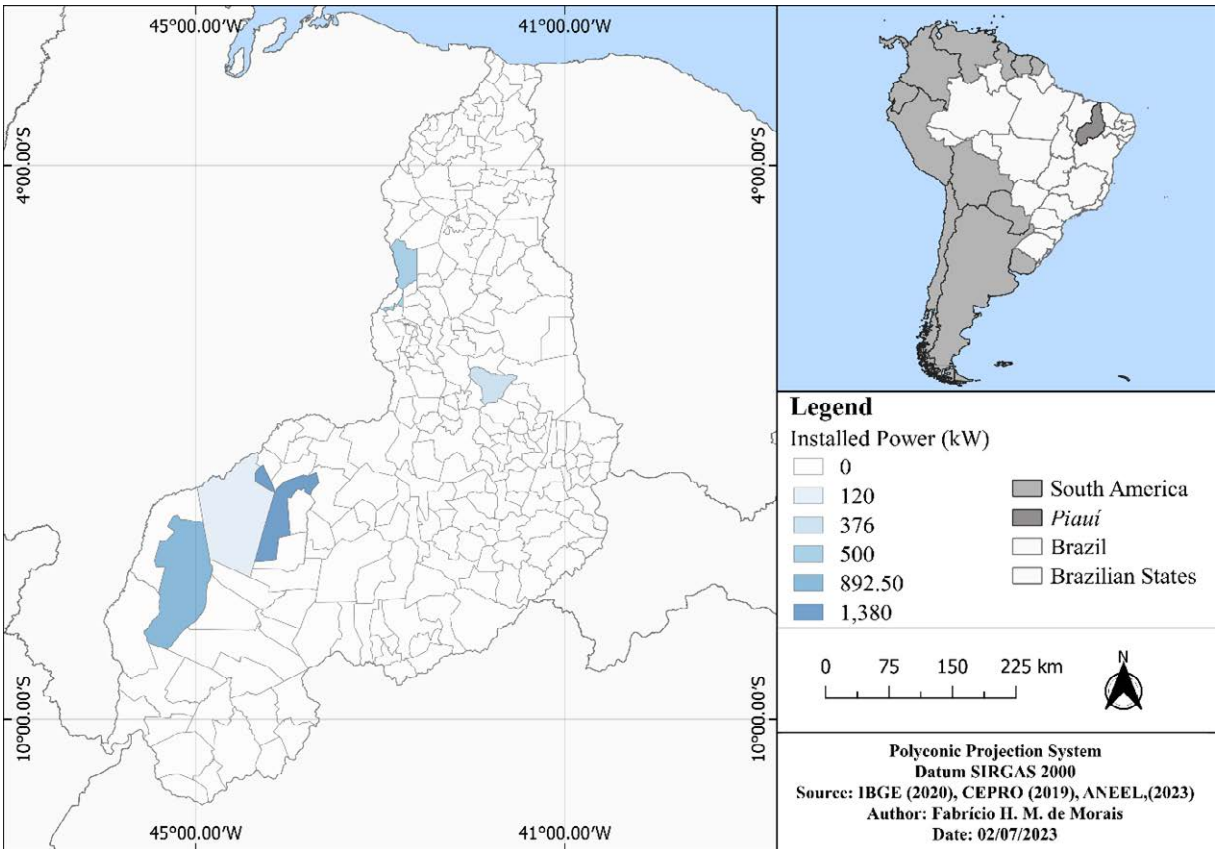

Figure 5 | Rural mini DG systems in *Piauí*'s municipalities

Source: Aneel (2023).

Identifying the factors that drive the installation of DG systems is essential to encourage its expansion. For instance, residential consumers have a high correlation between the degree of urbanisation and the domestic consumption of photovoltaic solar energy (FREITAS, 2022). From the perspective of the current Brazilian legislation, rural consumer units involve several activities such as rural and urban agriculture; rural residences; rural electrification cooperative enterprises; agro-industrial facilities with transformers rated at power levels less than 112.5 kVA; rural irrigation public service; agrotechnical schools; and aquaculture farming (ANEEL, 2021).

The matrix presented in Table 1 was used for the general characterisation of the agricultural sector in the development territories of *Piauí*. One could identify 245,601 agricultural establishments (AEs) in the state, with an average area of 40.76 ha, as shown in Table 3. *Tabuleiros do Alto Parnaíba* and *Chapada das Mangabeiras* territories stand out as the development territories with the largest projects, resulting in an average of 285.17 ha and 120.98 ha, respectively. In turn, *Entre Rios* territory has the largest irrigated area of 9345 ha and the highest annual agroindustry production corresponding to R$ 14.95 million (IBGE, 2019). However, it seems that the territories comprising the agricultural enterprises with the largest average areas are also the regions where family farming has the lowest representation, 10.61% and 24.52%, in contrast to an average of 38.49% when considering the state.

Table 3 | General characterisation of agricultural establishments in the Piauí's development territories

DT	*Number of AEs*	*Average área of the AEs (ha)*	*Per cent area dedicated to family farming*	*Total irrigated area of the AEs (ha)*	*Annual agroindustry production of the AEs (xR$1000.00)*
DT1	37,415	20.90	41.81%	9345	14,959.00
DT2	13,438	54.71	31.57%	2605	11,024.00
DT3	14,914	39.80	50.36%	2618	2814.00
DT4	5970	285.17	10.61%	1689	6949.00
DT5	15,244	10.76	54.27%	2919	9625.00
DT6	34,345	17.60	50.60%	2402	23,710.00
DT7	18,281	46.58	33.30%	1428	12,903.00
DT8	26,569	19.09	65.82%	1792	9173.00
DT9	20,773	32.49	73.35%	930	4737.00
DT10	18,054	31.12	65.08%	2397	1144.00
DT11	23,002	30.59	59.57%	1429	6582.00
DT12	17,596	120.98	24.52%	3825	15,127.00
Piauí	**245,601**	**40.76**	**38.49%**	**33,379**	**118,747.00**

Source: IBGE (2019).

Other aspects of agribusiness presented in Table 1 were also evaluated. In the development territories, 81.0% of agricultural enterprises have access to financing, and 13.92% are beneficiaries of government financing programs, resulting in standard deviations of 6.62% and 2.51%, respectively. Besides, 77.55% of producers live in the establishments, whereas 70.77% own the property, corresponding to standard deviations of 7.60% and 7.86%, respectively (IBGE, 2019). Unlike residential facilities where the installation of DG resources is often restricted to roofs, rural consumers have large areas available for this purpose, either on the ground or on the roof of sheds (HOLZBACH; RESENDE, 2022). However, the best alternative for rural electrification must rely on in-depth technical and economic studies (ALQANTANI; PATINO-ECHEVERRI, 2023).

The analysis of *Piauí*'s development territories shows that the distribution of rural micro DG systems strongly correlates with that of micro DG systems in general and with residential, commercial, and industrial systems, according to Table 4. However, rural mini DG systems present a weak correlation, unlike their microgeneration counterparts. It is reasonable to state that the configuration mechanism of the main microgeneration systems in the state has a similar behaviour. Future studies must be carried out to identify common driving factors, which could not be identified in the case of mini-generation systems installed in *Piauí.*

Table 4 | Correlation matrix associating rural, residential, commercial, and industrial mini and micro DG systems in Piauí's development territories

Total installed power of rural micro DG systems			*Total installed power of rural mini DG systems*		
	Correlation	Correlation Degree		Correlation	Correlation Degree
Ind.1	0.983	Strong	Ind.5	0.122	Weak
Ind.2	0.982	Strong	Ind.6	0.043	Weak
Ind.3	0.980	Strong	Ind.7	0.014	Weak
Ind.4	0.962	Strong	Ind.8	0.005	Weak

Source: Aneel (2023).

The fact that agribusiness aspects are strongly correlated with the total installed power of rural mini and micro DG systems in *Piauí*'s development territories was assessed in detail. Table 5 shows a moderate correlation between the availability of solar resources and socioeconomic indicators for rural micro DG systems. Among such aspects, human development and access to electricity are of major importance, the latter being a must for connecting the DG system to the electric utility network. Considering the state as a whole, Table 5 evidences that the factor that mainly explains the variance is the total irrigated area of agricultural establishments, which require electricity for water pumping systems. Besides, water is the main asset for increasing efficiency in the agricultural sector, where solar energy can bring prominent advantages (CHOWDHURY *et al*., 2022).

As for rural mini DG systems, one could identify a weak correlation involving all the analysed indicators. According to Table 5, the enterprises' average area is the state's main driving factor for installing mini DG systems in agricultural establishments. Large agricultural properties have a high energy demand, whereas large available areas enable the installation of high-power DG systems (HOLZBACH; RESENDE, 2022), thus corroborating the results of this study. The results obtained so far reflect the local reality of *Piauí*. However, the methodology can be applied to other sites with scientific relevance since similar data are available for all Brazilian municipalities.

Table 5 | Correlation matrix associating rural mini and micro DG systems with environmental, socioeconomic, and agribusiness factors

	Total installed power of rural micro DG systems		*Total installed power of rural mini DG systems*	
	Correlation	Correlation		Correlation
Ind.9	0.090	Weak	0.334	Weak
Ind.10	0.631	Moderate	0.267	Weak
Ind.11	0.698	Moderate	0.182	Weak
Ind.12	0.674	Moderate	0.218	Weak
Ind.13	0.722	Moderate	0.137	Weak
Ind.14	0.693	Moderate	0.194	Weak
Ind.15	0.505	Moderate	0.460	Weak
Ind.16	0.045	Weak	0.557	Moderate
Ind.17	0.125	Weak	0.907	Strong
Ind.18	0.126	Weak	0.354	Weak
Ind.19	0.918	Strong	0.049	Weak
Ind.20	0.264	Weak	0.065	Weak
Ind.21	0.505	Moderate	0.460	Weak
Ind.22	0.383	Weak	0.459	Weak
Ind.23	0.435	Weak	0.509	Moderate
Ind.24	0.487	Weak	0.527	Moderate

Source: Aneel (2023), IBGE (2019), PEREIRA et al. (2017) and Pnud (2023).

In addition, to better illustrate the study, scatter plots can be plotted as in Figures 6 and 7, which show the total power of the two types of rural DG systems as a function of the best correlation indices identified.

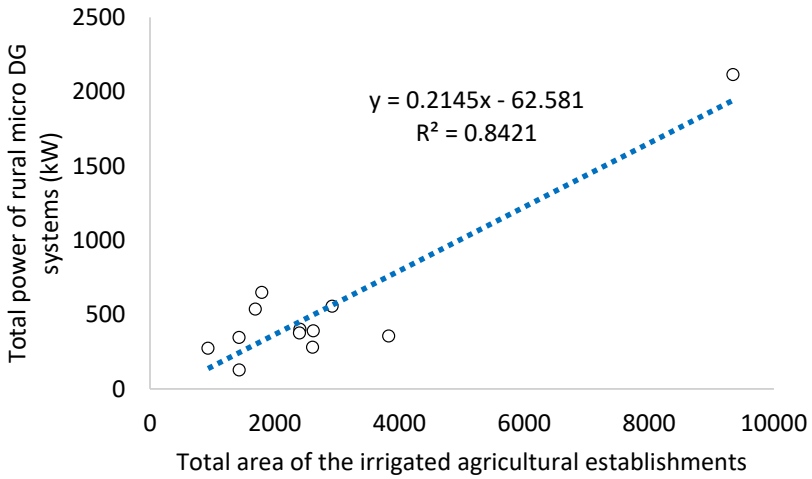

Figure 6 | Linear regression representing the total installed power of rural micro DG systems in Piauí's development territories

Source: Aneel (2023) and IBGE (2019).

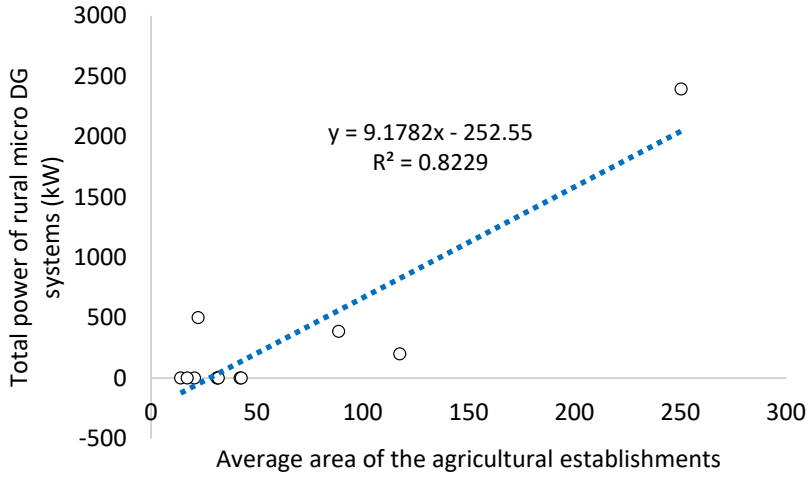

Figure 7 | Linear regression representing the total installed power of rural mini DG systems in Piauí's development territories

Source: Aneel (2023) and IBGE (2019).

The graphs also can show the equations that describe the behaviour of the assessed quantities and the R^2 coefficient that determines the model suitability. For the studied systems, the linear regressions evidence that the larger the total irrigated area of agricultural establishments, the higher the installed power of rural micro DG systems (R^2 equals 0.8421). Similar behaviour occurs with the installed power of rural mini DG systems in relation to the average area of agricultural enterprises (R^2 equals 0.8229). Finally, the data used in this research are available for all Brazilian municipalities. Thus, the described methodology can be promptly extended to other Brazilian states and regions.

4 CONCLUSIONS

The agricultural sector has a low representation in the national energy matrix, only 5.0%, corresponding to 8.41% and 14.77% of DG systems in terms of the number of units and installed power, respectively. However, this sector has an important role in the 2030 Agenda and is responsible for 27.4% of the Brazilian GDP, which evidences the great potential for the expansion of mini and micro DG. In addition,

increasing investments in rural infrastructure and developing technology to enhance agricultural productivity in developing countries, particularly in least-developed countries, are some key targets of the UN Agenda.

Based on this assumption, it was possible to develop a methodology that allows characterising the state of *Piauí* based on a territorial approach from environmental, socioeconomic, and agricultural indicators, correlating them with mini and micro DG systems that exist in rural areas to determine the factors that drive their installation. This solution applies to other states and can be extended to other studies from a regional and national perspective since identifying factors that drive the installation of DG systems is a key issue in encouraging its expansion.

It has been observed that the average HDI of the state is somewhat low, that is, 0.541, whereas a large portion of agricultural establishments does not have access to energy (18.54% on average). In turn, this scenario could be improved using renewable energy sources. A total of 245,601 agricultural establishments were identified in the state, with an average area of 40.76 ha, where 38.49% is dedicated to family farming activities. Besides, the state comprises an irrigated area of 33,379 ha (3.33%) and an agroindustrial production of R$ 118.74 million annually.

In this context, *Entre Rios*, which aggregates 31 municipalities with an average area of 621.68 km², stands from the positive and negative points of view. This territory has the highest HDI (0.595), in contrast to the highest number of agricultural establishments without access to energy in absolute terms (7674 units, corresponding to 21%). In addition, *Planície Litorânea*, which comprises 11 municipalities with an average area of 562.05 km², has the lowest HDI (0.541). In turn, *Chapada das Mangabeiras*, with 18 municipalities and an average area of 1377.1 km², has the highest number of agricultural establishments without access to energy in relative terms (5,653 establishments, that is, 32%). However, it is noteworthy that universal access to energy is not a reality in any of the territories studied, but this issue is of major importance for achieving the objectives of the UN Agenda 2030.

Considering an annual average global horizontal irradiation of 5.71 kWh/m² in the state, 4% higher than the average for the Brazilian Northeast region, all mini and micro DG systems consist of photovoltaic systems, which have an irregular distribution. Thus, it was possible to identify 29,457 systems, among which 99.54% correspond to micro DG units, with a total installed power of 298,103.76 kWh, thus representing 86.92% of the total installed power.

The present study has considered that rural DG systems are classified according to the criteria defined by Aneel. In this sense, consumers who develop rural and urban agriculture activities, rural residences, rural electrification cooperatives, agroindustrial facilities with transformers with rated power less than 112.5 kVA, public rural irrigation services, agrotechnical schools, and aquaculture farming can be considered agricultural establishments. Thus, 1.76% of the installed systems in *Piauí* are rural, representing 3.32% of the installed power. *Entre Rios* stands out again as the territory with the highest number and installed power of rural micro DG systems, 129 systems and 2,114.95 kW. In turn, *Tabuleiros do Alto Parnaíba*, which is a territory that comprises 12 municipalities and an average area of 2767.55 km², has the highest installed power and number of mini DG systems, that is, seven systems and 2,392.50 kW.

One can state that the distribution of rural micro DG systems in *Piauí* strongly correlates with the installation of micro DG systems. As for systems installed in residential, commercial, and industrial facilities, an average correlation of 0.98 denotes that the distribution of installed facilities is motivated by some common factors identified in the case of rural micro DG systems. However, a weak correlation was found for rural mini DG systems, where an average correlation of 0.05 denotes that the dispersion of existing systems is associated with particular configurations.

It has been observed that rural micro DG systems have a moderate correlation with the availability of solar resources and socioeconomic indicators. There is a strong correlation with the total irrigated area of agricultural establishments that usually rely on electricity as an important asset for water pumping systems. Overall, it is reasonable to state that this is the main factor that drives the installation of micro DG systems in the state. On the other hand, rural mini DG systems have a weak correlation with almost all the analysed indicators, except for the average area of agricultural establishments. Since the latter indicator presented a strong correlation, it is mainly responsible for driving the installation of mini rural DG systems in the state.

Considering that rural consumers are just one of seven types of consumers classified by the Aneel (rural, residential, commercial, industrial, governmental, public lighting, and public services), as well as that the study comprises a single Brazilian state, possible future work includes extending the methodology to wider regions while incorporating all other types of consumers. Thus, one can more clearly identify the main aspects associated with the strong correlation between the distribution of the various distributed micro DG systems.

REFERENCES

AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA. **Relação de empreendimentos de Geração Distribuída**. Brasília: Aneel, 2023. Available at: https://dadosabertos.aneel.gov.br/dataset/relacao-de-empreendimentos-de-geracao-distribuida/. Accessed on: January 2023.

AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA. **Resolução Normativa Aneel Nº 1.000, de 7 de dezembro de 2021**. Estabelece as Regras de Prestação do Serviço Público de Distribuição de Energia Elétrica; revoga as Resoluções Normativas Aneel nº 414, de 9 de setembro de 2010; nº 470, de 13 de dezembro de 2011; nº 901, de 8 de dezembro de 2020 e dá outras providências. Brasília: Aneel, 2021.

ALMEIDA, H. A.; ALMEIDA, E. C. V. Potencial da energia solar fotovoltaica no Semiárido nordestino. **Concilium**, v. 22, n. 2, p. 197–210. Available at: https://doi.org/10.53660/CLM-111-130

ALQANTANI, B. J.; PATINO-ECHEVERRI, D. Identifying Economic and Clean Strategies to Provide Electricity in Remote Rural Areas: main-grid extension vs. distributed electricity generation. **Energies**, v. 16, n. 2, 2023. Available at: https://doi.org/10.3390/en16020958.

ARNAWAN, H. *et al*. Evaluation of 20 kV Distribution Network Losses In Radial Distribution Systems Due to Distributed Generation Penetration. **Journal of Physics**. Conference Series, 2129, v. 2021. Available at: https://doi:10.1088/1742-6596/2129/1/012085.

AZEVEDO JÚNIOR, W. C.; SANTANA, A. C. O produto interno bruto do Brasil ajustado pela depreciação do solo agrícola. **Revista de Economia e Sociologia Rural**, v. 60, n. 2, 2022. Available at: https://doi.org/10.1590/1806-9479.2021.228505.

BOFF, L. **Sustentabilidade**: o que é – o que não é. Petrópolis: Vozes, 2017.

BORGES, F. F.; LUNA, F. M. Tecnologias sociais e energias renováveis na agricultura familiar: experiências no NDTS/IFPB e parceiros. **Revista Praxis: saberes da extensão**, v. 5, n. 10, p. 112-119, 2017. Available at: http://dx.doi.org/10.18265/2318-23692017v5n10p112-119.

CENTRO DE ESTUDOS AVANÇADOS EM ECONOMIA APLICADA. **PIB do agronegócio cresceu abaixo das projeções**. São Paulo: USP, 2022.

CHOWDHURY, H. *et al*. A simulation study of techno-economics and resilience of the solar PV irrigation system against grid outages. **Environmental Science and Pollution Research**, v. 29, p. 64846–64857, 2022. Available at: https://doi.org/10.1007/s11356-022-20339-2.

COSTA, V. B. F. *et al*. Socioeconomic and environmental consequences of a new law for regulating distributed generation in Brazil: a holistic assessment. **Energy Police**, v. 169, 2022. Available at: https://doi.org/10.1016/j.enpol.2022.113176.

DINIZ, M. T. M. *et al*. Análise da influência de Variáveis Socioeconômicas na distribuição de casos e óbitos de Covid-19 no Brasil. **Geografia Ensino & Pesquisa**, v. 25, n. 43, 2021. Available at: https://doi.org/10.5902/2236499461365.

EMPRESA DE PESQUISA ENERGÉTICA. **Brazilian Energy Balance**. Brasília: EPE, 2022.

FREITAS, B. M. R. What's driving solar energy adoption in Brazil? Exploring settlement patterns of place and space. **Energy Research & Social Science**, v. 89, 2022. Available at: https://doi.org/10.1016/j.erss.2022.102660.

FREITAS, R. A. B. *et al*. Patentes e espaço geográfico: uma análise espacial do território piauiense. **Research, Society and Development**, v. 10, n. 9, 2021. Available at: https://doi.org/10.33448/rsd-v10i9.17949.

GARLET, V. *et al*. Sustainable Development Goals – SDG: an analysis of the main characteristics of publications. **RISUS. Journal on Innovation and Sustainability**, v. 13, n. 2, p. 14-26, 2022. Available at: https://doi.org/10.23925/2179-3565.2022v13i2p14-26.

GIMENES, T. K. *et al*. Impact of distributed energy resources on power quality: Brazilian scenario analysis. **Electric Power Systems Research**, v. 211, 2022. Available at: https://doi.org/10.1016/j.epsr.2022.108249.

GONZÁLEZ, A. B. P.; VIGLIO, J. E.; FERREIRA, L. C. Energy communities in sustainable transitions – The South American Case. **Sustainability in Debate**, v. 13, n. 2, p. 156–174, 2022. Available at: https://doi.org/10.18472/SustDeb.v13n2.2022.41266

HOLZBACH, M.; RESENDE, A. S. Photovoltaic generators: use by rural customers in Mato Grosso State. **Revista Engenharia na Agricultura**, v. 30, 2022. Available at: https://doi.org/10.13083/reveng.v30i1.12689.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Censo agropecuário 2017**: resultados definitivos. Rio de Janeiro, IBGE, 2019. Available at: https://sidra.ibge.gov.br/pesquisa/censo-agropecuario/censo-agropecuario-2017/resultados-definitivos/. Accessed on: February 2023.

JEAN, W.; BRASIL JUNIOR, A. C. P. Solar model for Rural Communities: Analysis of Impact of a Grid-Connected Photovoltaic System in the Brazilian semi-arid region. J**ournal of Sustainable Development of Energy, Water and Environment Systems**, v.10, n. 3, 2022. https://doi.org/10.13044/j.sdewes.d9.0405.

LAMIN, H. **Universalização do serviço público de energia elétrica e os Programas Luz para Todos e Mais Luz Amazônia**. Brasília: Aneel, 2021.

LEDUCHOWICZ-MUNICIO, A. *et al.* Last-mile rural electrification: lessons learned from universalisation programs in Brazil and Venezuela. **Energy Policy**, v. 167, 2022. Available at: https://doi.org/10.1016/j.enpol.2022.113080.

LIRA, M. A. T. *et al*. Characterisation of Wind Behaviour in Piauí in Order to Utilise Wind Energy. **Revista Brasileira de Meteorologia**, v. 32, n. 1, 2017. Available at: https://doi.org/10.1590/0102-778632120150712.

MEDEIROS, S. E. L. *et al*. Influence of climatic variability on the electricity generation potential by renewable sources in the Brazilian semi-arid region. **Journal of Arid Environments**, v. 184, 2021. Available at: https://doi.org/10.1016/j.jaridenv.2020.104331.

MENDES, P. D. A. G. *et al*. Public Policies and Adaptation to Climate Change: three case studies in the Brazilian semi-arid region. **Sustainability in Debate**, v. 13, n. 3, p. 227-245, 2022. Available at: https://doi:10.18472/SustDeb.v13n3.2022.46064

MICROSOFT. **Power BI Desktop**, version 2.112.603.0. Microsoft Corporation, 2022.

MICROSOFT. **Microsoft Excel 2021 MSO**, version 2306. Microsoft Corporation, 2021.

MORAIS, M. D. C.; SOUSA, A. M. B.; ARAÚJO, C. F. S. Family Farming in Piauí: a reading of the agricultural census 2017. **Revista Econômica do Nordeste**, v. 51, p. 71-91, 2020.

MOTUZIENĖ, V. *et al.* A Review of the Life Cycle Analysis Results for Different Energy Conversion Technologies. **Energies**, v. 15, n. 22, 2022. Available at: https://doi.org/10.3390/en15228488

OPEN SOURCE GEOSPATIAL FOUNDATION. **QGIS Geographic Information System**, version 3.28.5. OSGEO Foundation, 2023.

PEREIRA, E. B. *et al*. **Atlas Brasileiro de Energia Solar**. 2. ed. São José dos Campos: Inpe, 2017. Available at: http://doi.org/10.34024/978851700089.

PROCÓPIO, G. B. *et al*. Análise da vulnerabilidade social sobre o indicador de crianças extremamente pobres nas regiões metropolitanas do Brasil. **Revista de Estudos Sociais**, v. 22, n. 44, p. 5-14, 2020. Available at: https://doi.org/10.19093/res7902

PROGRAMA DAS NAÇÕES UNIDAS PARA O DESENVOLVIMENTO. A**tlas do Desenvolvimento Humano no Brasil – Ranking**. Brasília: Pnud, Ipea, FJP. Available at: http://idhm.org.br/ranking/. Accessed on: February 2023.

SILVA, G. D. P. *et al*. Environmental licensing and energy policy regulating utility-scale solar photovoltaic installations in Brazil: status and future perspectives. Impact **Assessment and Project Appraisal**, v. 37, 2019. Available at: https://doi.org/10.1080/14615517.2019.1595933.

SILVA, O. A. V. O. L. *et al*. **Etiquetagem do uso da energia**: uma nova proposta de rotulagem ambiental. Teresina: EdUESPI, 2022.

SILVA, O. A. V. O. L. *et al*. Expansion of photovoltaic systems in multicampi higher education institutions: evaluation and guidelines. **Revista Brasileira de Ciências Ambientais**, v. 56, n. 4, p. 697-709, 2021. Available at: https://doi.org/10.5327/Z217694781009.

SILVA, S. A.; CASTRO, L. G. Two-dimensional statistical analysis applied. **Revista Ibero-Americana de Humanidades, Ciências e Educação**, v. 8, n. 4, 2022. Available at: https://doi.org/10.51891/rease.v8i4.5051

SOARES, A. M. de A.; BARRETO, C. G. Disputes and narratives on the distributed generation of electricity in Brazil: setbacks for the 2030 Agenda for sustainable development and the Paris Agreement. **Sustainability in Debate**, v. 13, n. 3, p. 32–71, 2022. Available at: https://doi.org/10.18472/SustDeb.v13n3.2022.45621

SUPERINTENDÊNCIA DE ESTUDOS ECONÔMICOS E SOCIAIS. **Piauí em Números**, 11. ed. Teresina: Cepro, 2019.

UNITED NATIONS. **Transforming Our World**: the 2030 Agenda for Sustainable Development United Nations. New York: UN, 2015.

WORLD BANK. **Report: Covid-19 Slows Progress Toward Universal Energy Access**. Washington: World Bank: 2023. Available at: https://www.worldbank.org/en/news/press-release/2022/06/01/report-covid-19-slows-progress-towards-universal-energy-access. Accessed on: July 2023.

Urban road cyclability: indicators for the municipality of Belo Horizonte- MG, Brazil

Ciclabilidade viária urbana: indicadores para o município de Belo Horizonte- MG, Brasil

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ABSTRACT

How people move around in large Brazilian cities reflects a process of production and appropriation of urban space. The transport system is characterised by the increasing rate of individual motorisation and the precariousness of public transport services. The general objective of this paper is to evaluate the level of road cycling in the city of Belo Horizonte/Minas Gerais/Brazil, based on the proposition and analysis of indicators to assess the degree of adequacy of urban roads for bicycle use as a transport mode. The results indicate that many of the roads in Belo Horizonte have good cycling levels. Given its topography and climate, these findings go against commonly held views that consider the municipality inappropriate for cycling as a mode of transport. In reality, Belo Horizonte has a very underused high cycling potential, especially if there were investments to expand the exclusive/preferred road infrastructure.

Keywords: Cyclability. Urban mobility. Active Transport. Non-Motorized Transport.

RESUMO

A maneira como as pessoas se deslocam nas grandes cidades brasileiras é reflexo do complexo processo de produção e apropriação do espaço urbano, que no sistema de transportes se caracteriza pela crescente taxa de motorização individual e na precariedade da prestação de serviços de transportes públicos. O objetivo geral deste paper é avaliar o nível de ciclabilidade viária do município de Belo Horizonte/Minas Gerais/Brasil, tendo como base a proposição e análise de indicadores para avaliar o grau de adequação das vias urbanas ao uso da bicicleta como modo de transporte. De um modo geral, os

resultados obtidos indicam que significativa parcela das vias de Belo Horizonte apresenta bons níveis de ciclabilidade. Esse desempenho costuma contrariar o senso comum que tende a considerar o município, dada sua topografia e clima, como inapropriado ao uso da bicicleta como modo de transporte. Na verdade, Belo Horizonte possui elevado potencial ciclável ainda muito subutilizado, especialmente se existir um investimento na ampliação da infraestrutura viária exclusiva/preferencial.

Palavras-chave: Ciclabilidade. Mobilidade Urbana. Transporte Ativo. Transporte não Motorizado.

1 INTRODUCTION

The movement of goods and people within cities has induced and led to the development of the road system, thus increasing the need for transit and transportation services, as researched by authors such as Barouche (2014), Brazil Vasconcellos (1996), Cardoso (2007), Hansen (1959), Jones (1981), Landis (1994), and Pereira *et al*. (2011). Brazil faces successive failures due to inefficient low-quality public transportation systems, which rely heavily on buses. The legal obligation to execute the National Urban Mobility Policy (PNMU), defined by Law 12,587, January 3, 2012 (BRAZIL, 2012), was an attempt to mitigate the existing deficiencies in the country, mainly due to the prevalence of a model centred on the collective bus system and individual motorised transport. However, as indicated by Vasconcellos (1996), despite the PNMU, it is clear that a lack of willingness to adopt policies less focused on the primacy of motorised urban transport motorisation persists, limiting the space available to new trends that potentially benefit urban mobility more efficiently and sustainably.

The existing financing model of Brazilian public transport is primarily supported by tariff collection. However, 2009 data from the National Association of Urban Transport Companies (ANTU) show that 37 million Brazilians routinely did not use public transport due to their inability to pay the fares. The situation of the Brazilian urban public transport system has been exacerbated by the growth of motorised individual transportation at the expense of public transportation. Barouche (2014) leading to a continual loss of users. Despite the number of resources invested in urban transport systems, problems related to mobility and accessibility have been aggravated by the growth of the vehicle fleet, especially in the country's large urban centres. According to figures from the National Traffic Department of the Ministry of Infrastructure, over 60 million automobiles were on the road in 2023. The increase in congestion overloads the road system and worsens the public transport system. In Belo Horizonte, the fall in the relative participation of intra-urban trips by bus and bicycle confirms the imbalance caused by the historical prioritisation of less sustainable modes (Lessa *et al*., 2019). The last two Origin and Destination Surveys (ODS), produced by the Development Agency of the Metropolitan Region of Belo Horizonte, a governmental entity administered by the State Government of Minas Gerais, indicate that the total of regular daily trips by bus and bicycle shrank from 43.49 and 0.48% to 23.28 and 0.41%, between 2002 and 2012, respectively. In the same period, the share of car trips increased from 23.03 to 30.55%. This increase in car use is mainly due to the migration of public transport users to individual modes of transport, especially cars and motorcycles. Consequently, road congestion is no longer an exclusive problem at peak times.

It is no coincidence that the demand for bicycle use has gradually gained prominence in debates on urban mobility, both in academic and political circles, even if its practical use as a means of transport is still incipient. Several studies, including more recent research (BUEHLER; DILL, 2016; ELIOU *et al*., 2009; FHWA, 2002; GHOLAMIALAM; MATISZIW, 2019; NIELSEN; SKOV-PETERSEN, 2018; RIETVELD; DANIEL, 2004; WAHLGREN, 2011), emphasise that promoting non-motorized transport can be part of a transport planning strategy that includes the objective of reversing urban problems caused by prioritising car use. When used as a practical transportation mode, the bicycle can stimulate greater

social equity by providing the population access to productive activities at a reduced cost while promoting a more physically active lifestyle, thus reducing sedentarism. However, myths regarding the potential use of bicycles in Belo Horizonte persist, including the climate (hot and humid) and topography (there are roads/streets with steep slopes). Regarding the latter, Nobrega (2016) demonstrates this false impression when identifying and mapping the road network's concentrated patterns and high gradients in Belo Horizonte, Minas Gerais.

The result is an incorrect impression that the city is unsuitable for cycling, which is usually accepted as a leisure/sports activity, restricted to certain spaces and specific times, generally at weekends. Given the above, three main issues require further investigation. First, the factors that should be considered to assess the cyclability level. In the case of Belo Horizonte/MG, the pathways with greater or lesser cyclable potential must also be identified. Thirdly, with investment in localized infrastructure, what are the potential road expansion vectors that could encourage the use of bicycles? Considering these issues, this paper aims to evaluate the level of road cyclability in the city of Belo Horizonte/MG, Brazil, based on the proposal and analysis of aggregated and disaggregated indicators to assess how suitable the urban roads are for the use of bicycles as a mode of transport.

2 URBAN CYCLABILITY: CONCEPTS, MEASUREMENT FACTORS, AND ANALYSIS MODELS

"Cyclability" is often perceived as synonymous with "bicycle-friendly." Although both involve a person's ability to move around by bicycle or the prevalence of a cycling-friendly environment, this characterization tends to lead to inaccuracy, and the literature lacks consensus on its definition. For César (2014), for example, cyclability reflects how good or bad a city is for bicycles as a mode of transport. In the same work, this author states that a city may have favourable bicycle use characteristics without a single designated kilometre of cycle paths. Similarly, a city may have several kilometres of cycle paths and low cyclability due to other limiting factors, such as relief. Other authors, such as Dill and Carr (2003), Krenn *et al*. (2015), Silva (2014), Tuner *et al*. (1997), point out that the concept of cyclability extends to the evaluation of the quality of streets focused on bicycle use in an urban area. In general, this assessment considers cyclists' comfort and safety and is not explicitly associated with the existence of appropriate cycling infrastructure.

Alternatively, Eliou, Galanis, and Proios (2009); Gholamialam and Matisziw (2019); Kirner and Sanches (2011); Nordström and Manum (2015), and Wahlgren (2011) evaluate cyclability according to existing cycling infrastructure in a given location. Thus, the definition of cyclability implies the extent to which the cycling network provides for appropriate bicycle use. This definition is also close to the Bicycle Level of Service (BLOS), used by Botma (1995), Dixon (1996), Jensen (2007), Petrisch *et al*. (2007), and the Highway Capacity Manual (2010), which only consider factors related to local cycling infrastructure and ignore other factors such as relief, climate, and socioeconomic aspects. Despite adopting a similar approach, Grigory (2008), Lowry *et al*. (2012), and Nielsen and Skov-Petersen (2018) consider that cyclability is also an assessment of the ability and efficiency of the cycling network to connect to essential destinations. Therefore, they consider the quality and distances of the journeys.

The quality of the infrastructure can also interpret cyclability and serves as a measure of cyclists' access to desired destinations. In this sense, cyclability refers to cyclists' inherent ease of performing their regular trips. In other words, cyclability refers to the "friendliness" of a place for bicycle users in terms of comfort and safety. Therefore, environmental factors such as relief, climate, land-use diversity, and factors related to cyclists' safety and comfort, like infrastructure provision, preferential treatment for bicycles, and parking availability, should be considered essential. In general, based on the literature consulted, discussions on cyclability examine bicycle mobility based on the European and, to a lesser extent, North American and Asian realities, as demonstrated by, for example, Buehler and Dill (2016), Forester (1993), Fuller *et al*. (2013), Manum *et al*. (2017), Nordström and Manum

(2015). Factors such as spatial structure have also had an evident impact on bicycles as a mode of transport. In the Brazilian case, public policies aimed at the movement of people in large urban centres have historically been formulated primarily to serve individual motorized transport (BAROUCHE, 2014; CARDOSO, 2007; VASCONCELLOS, 2011; VILLAÇA, 1998). Therefore, a different approach to the concept is required, adapted to the local reality, marked by a high level of inequality and inadequate planning and management. Likewise, identifying the factors contributing to cycling is a fundamental step in guiding methodological procedures and constructing models and methods to estimate local cyclability. Therefore, the following section briefly reviews the literature on the factors, be they environmental, social, or even structural (dedicated lanes, separators/flow barriers, for example), which are considered determinants in the choice of the bicycle as a mode of transport.

2.1 FACTORS AND VARIABLES INFLUENCING THE USE OF THE BICYCLE AS A MODE OF TRANSPORT

According to the *Federal Highway Administration* (FHWA, 2002), a division of the United States Department of Transportation, an individual's decision to use a non-motorized mode of transport is a complex process with three main conditions. The first is the individual's perception of their initial needs. Depending on the reason for their journey, they will assess whether the alternative mode can carry out their trip. Their perception of the bicycle's ability to adequately carry out a shopping or work trip is quite instructive. Secondly, they consider the trip's characteristics, such as whether the planned route has preferential bicycle lanes or favourable climatic conditions. Routes with preferential treatment can encourage bicycle use because they offer cyclists more comfort and safety, while good weather conditions do not discourage the city dweller from using alternative transport modes. Finally, the third condition considers the characteristics of the destination. Factors include accessibility to a given location, facilities such as bicycle racks, and the risk of theft or depredation (FHWA, 1992).

These conditions cover several factors that individuals consider before starting their bike trip. The FHWA suggested categorising these factors into two groups: subjective and objective. Subjective factors relate to each individual's unique characteristics, which can only be identified by research with the target audience. Cultural perspective, physical condition, daily habits, appreciation of physical activities, and feeling safe in traffic are examples of subjective factors. The objective factors consider both the environmental characteristics of a given place (climate and relief) and the characteristics of the infrastructure (adequate infrastructure for bicycles). For Pezzuto and Sanches (2004), the factors presented by FHWA are 1) Subjective: Travel length; Traffic safety; Convenience; Travel cost; Value attributed to time; Valuing of physical exercise; Physical conditions; Family circumstances; Daily habits; Attitudes of social values; and Social acceptability. 2) Objective: Environmental characteristics (Climate and Topography); Infrastructure characteristics; Adequate bicycle infrastructure; Accessibility and continuity of routes; and Transport alternatives.

Other authors have a similar perspective to Sener *et al*. (2009) and classify the factors that influence bicycle use into three categories: 1) Demographic, such as age, sex, race, vehicle ownership, and family income; 2) Attitudes and perceptions, such as the perception of safety and protection, perception of time vs cost, and attitudes regarding the practice of physical activities; 3) Characteristics of the region, bicycle-related infrastructure and amenities, such as land use, environmental factors, the existence of parking lots, and the provision of showers and lockers in the workplace, among others. Wahlgren (2011) proposes organizing environmental, traffic, and social factors. The first set includes the cycle network, green areas, attractiveness, route, relief, stops, and distance. The second category covers factors that vary over time, such as pollution, noise, traffic flow, car speed, cyclist speed, and road congestion. The latter group comprises factors representing the relationship between pedestrians, drivers, and cyclists.

Rietveld and Daniel (2004) also believe that bicycle use is related to personal characteristics, such as income, age group, gender, and activity patterns, which can predict this choice. Local government initiatives, the quality of the bicycle network, and the general costs of other modes of transport directly influence what the authors call "widespread bicycle costs" (Figure 1). Rather than focusing only on monetary value, these costs consider diverse factors. Namely: 1) Travel time depends on the cities' spatial structure and the adequacy of the cycling infrastructure; 2) Physical capacity and comfort refer to the layout and quality of the roads destined for bicycle use, the user's physical fitness, and the relief and climatic conditions; 3) Road safety refers to the risk of being involved in accidents with motorized transport modes; 4) Risk of theft and robbery: results from the quality of the push-bike and the distance travelled on the routes, that is, the better the bicycle, the greater the probability of theft or robbery on longer and more frequent trips; 5) Monetary cost of the bicycle includes the costs of acquisition, maintenance, and parking. The "widespread costs of motorized modes of transport" are noteworthy as the difference between the costs will influence whether the bicycle is used.

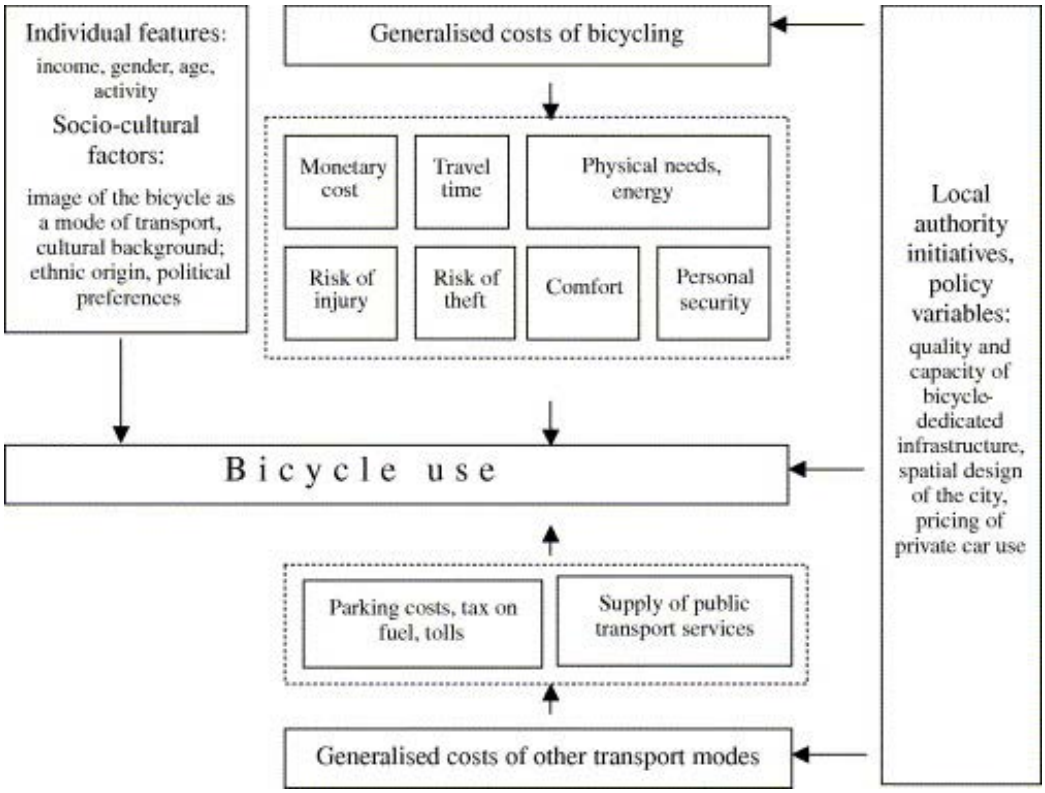


Figure 1 | General picture of the factors and variables that influence bicycle use

Source: Extracted from Rietveld and Daniel (2004).

Table 1 shows the primary factors and variables used to characterise cyclability in the cities analysed by Rietveld and Daniel (2004). Their results indicate that in cities with high population density, the contribution of bicycle trips to the total number of trips is reduced by more than 8%. Similarly, in places with a proportionally larger young population, bicycle use increases by 4%. On the other hand, increased participation of voters of the Liberal Party is associated with less cycle travel. In locations with higher education and vocational training, there is an increase of 7.4%. In a hilly city, the reduction in bicycle use can reach 74%. An additional car per capita reduces the share of travel by 26%. Politically speaking, the index shows a positive correlation between local government initiatives and bicycle use. The final two factors related to the outcomes of implemented local policy show that bicycle use is reduced by 0.05% when there is a gain of one percentage point of people dissatisfied.

Table 1 | Cyclability analysis factors and variables in cities in the Netherlands

Factors	*Variables*
Characteristics of the city	Demographic density
	Concentration of human activities
	Proportion of young people
	Presence of university and technical school
	Proportion of Liberal Party voters
	Proportion of foreigners
	Income increases of the population.
	Number of cars per capita
	Terrain
Political Efforts	Bicycle infrastructure
	Frequency of stops at intersections
	Availability and parking costs
	Frequency of obstacles
	Pavement quality
	Speed (percentage of rides where the bike is faster than the car)
Political consequences	Security Level
	Degree of satisfaction

Source: Adapted from Rietveld and Daniel (2004).

Other studies on the relationship between factors/variables and bicycle use have similar results to Rietveld and Daniel (2004). Ashley and Banister (1989), Axhausen and Smith (1986), Forester (1993), Lott *et al*. (1977), Ortuzar *et al*. (2000), Pucher and Buehler (2008), and Sorton and Walsh (1994) state that motor vehicle ownership, income, the presence of higher education facilities, user age, distance and duration of travel, topography, and cycling infrastructure are factors that undoubtedly affect bicycle use in urban areas. Although less frequent than European studies, research in Brazil on bicycle use and the assessment of cyclability also raise factors that may or may not encourage their use. Prodivelo and Sanches' (2010) research aimed to identify the factors that determine the choice of this mode of transport and evaluate individuals' perceptions of cycling. To this end, they applied an attitude survey to 447 cyclists and non-cyclists in the cities of São Carlos, Rio Claro, and São Paulo.

The analysis of this survey indicates that the factors with the most significant positive response among the interviewees are those that establish cycling as a cheap and healthy form of transport. Regarding the limitations of bicycle use, 67% of the interviewees stated that they would cycle more often if there were more bicycle infrastructure. Lack of security was considered an impediment by 56% of respondents. César (2014), for example, interviewed 2,925 people from all over Brazil to assess the cyclability of Brazilian cities. In the questionnaire, cyclists evaluated the following factors: relief, climate, physical barriers, city size and diversity of land use, pollution, integration with public transport, road conditions, security, personal safety, continuity of cycling infrastructure, linearity, safety and comfort, local culture, and urban mobility management.

2.2 MODELS AND METHODS FOR ASSESSING URBAN CYCLABILITY

Three main models/methods are used to analyse urban cyclability. The first is based on Bicycle Suitability, the second is estimated by cyclists' behaviour and the Spatial Syntax, and the last uses Multicriteria Analysis. In bicycle suitability models, several attributes of a given linear section of road receive a certain number of points combined to calculate a score qualifying the segment in a spectrum

from desirable to undesirable. Thus, it is possible to determine the most suitable bicycle routes. The models are generally distinguished by the attributes selected, the points system, and their distribution. Notably, each model's authors provided theoretical and empirical findings that support the associated values and indicate the inclusion or exclusion of specific attributes.

Bicycle suitability models are applied according to the levels of tension, suitability, and capacity of roads. According to Turner *et al*. (1997), the level of tension is a simple concept that incorporates the three most intuitive stress factors experienced by cyclists in urban traffic, namely: traffic volume, lane width, and motor vehicle speed. In this regard, Sorton and Walsh (1994) argue that cyclists avoid certain places in a city, for example, to escape the harassment of heavy traffic and the unease of travelling on narrow streets with a large volume of motor vehicles. Thus, Sorton and Walsh developed a model using the Bicycle Stress Level (BSL) metric, quantifying this stress in urban and suburban streets in Madison, Wisconsin, USA. The BSL is applied by dividing the streets into segments according to their intersections and then stipulating the criteria to quantify the three factors individually. The follow-ups are classified after the values have been entered (SORTON; WALSH, 1994).

The level of road adequacy is determined by a more varied range of models that consider traffic volume, the width of the carriageway, the speed limit for motor vehicles, the condition of the paving, and the location of the cycling infrastructure as characteristics making roads more or less suitable for bicycle use. As pointed out by Turner *et al*. (1997), these models have the advantage of limited input variables but do not incorporate hypothetical factors that could affect the use of bicycles. In this regard, Davis (1987) developed the Bicycle Safety Index Rating (BSIR) to provide a mathematical model that indexes the stipulated safety values to the roads' physical characteristics. The BSIR comprises the Road Segment Index (RSI), which evaluates individual segments of the roads, and the Intersection Evaluation Index (IEI), which examines intersections between road sections. The indexes use the following input variables: Average daily traffic volume per lane; Speed limit of motorised vehicles; Lane width; Paving factor (pavement condition or presence of drainage utility holes); Location factor (parking and conversion lanes, gradient, declivity, continuity of cycling paths and adjacent land use); and Signaling/ intersections. Another metric used to determine road suitability is the Interaction Hazard Score (IHS), developed by Landis (1994) to assess the suitability of roads for cycling in American urban areas such as Birmingham, Alabama. Like the BSIR, the IHS also uses factors related to cyclist safety; however, it unifies all the factors in a single general indicator. Landis developed questionnaires based on cyclists' perceptions to adjust the values and calibrate the models. In addition to the factors BSIR uses, the HIS includes the volume of heavy vehicles.

The metric used to measure track capacity is the Bicycle Level of Service (Blos), which Lowry (2012) views as the most current and frequent analysis. Studies such as those by Dowling (2008), Gholamialam and Matisziw (2019), Grigory (2018), Manum *et al*. (2017), and Szyszkowicz (2018) use or mention Botma (1995) and Dixon's (1996) Blos. The Blos is considered state-of-the-art in assessing cyclability and was developed to complement the Highway Capacity Manual (HCM) or Road Capacity Manual for non-motorized travel (LOWRY, 2012). Lowry (2012) also proposes that the Blos' calculation weighs ten factors that influence bicycle use: 1) the width of the road for motor vehicles; 2) width of cycle paths; 3) width of cycle lanes; 4) proportion of parking lots for motor vehicles; 5) volume of traffic; 6) speed of vehicles; 7) the percentage of heavy vehicles; 8) paving condition; 9) presence of obstacles; and 10) proportion of roads with preferential treatment for bicycles. These factors are combined in a nonlinear equation designed to produce a numerical score representing cyclists' perceptions of comfort and safety.

Despite showing some functionality in their research context, the models presented have significant deficiencies. The metrics do not consider attributes unrelated to road infrastructure, such as topography, landscape quality, and demographics. According to Tralhão and Ribeiro (2014), cyclists deviate from the shortest route mainly to avoid areas of rugged relief. Secondly, as previously stated, metrics such as Blos can only be applied on routes with preferential bicycle treatment. Finally, the methods were developed

in the USA, which raises uncertainties about their applicability to Belo Horizonte. Unlike the proposals based on classical methods, models estimated by cyclists' behaviour and Spatial Syntax provide alternative techniques that are also effective in evaluating cyclability. Cyclability can also be measured and evaluated based on the geometric characteristics of urban space, such as road linearity and the angles between intersections. When related to cyclability or walkability, spatial syntax can be very helpful. Pereira *et al*. (2011) suggest that since urban configuration spatially affects the displacement pattern of people and vehicles through the city, it is possible to predict which roads will be used the most. Manum *et al*. (2017) and Nordström and Manum (2015) applied spatial syntax to model the cyclability of Oslo, Norway, and Gothenburg, Sweden, demonstrating that the angular minimisation of intersections is essential for route choice. According to the authors, in addition to intersections, the number of stops (signalling) and relief most influenced the speed and time of bicycle trips.

Multicriteria Analysis models have also proved to be appropriate in delineating cyclable roads and routes, as highlighted by Carvalho (2016), Gholamialam and Matisziw (2019), Rybarczyk and Wu (2010) and Silva (2014). Satisfactory results in its application in urban mobility planning is a factor that has weighed heavily in its selection. One advantage of multicriteria analysis is that it can be easily associated with a GIS. In this regard, Malczewski (2006) justifies that although GISs and multicriteria decision methods are two distinct research areas, urban planning problems can benefit from combining their techniques and procedures. Compared to other methods, multicriteria analysis is also advantageous as it does not distinguish the data's origin, whether an in-loco primary source or secondary information from government management bodies. It is noteworthy that secondary data fully supports the methodology proposed in this research, guaranteeing its remote applicability without sending an investigative team to the field. This method was selected after analyzing the options.

It is essential to highlight that multicriteria analysis is a mathematical method that allows different alternatives (or scenarios) to be compared to direct decision-makers to a weighted choice, as Jordão and Pereira (2006) pointed out. It is not a coincidence that its use is expanding in environmental quality, sustainability, and transport planning studies (SILVA, 2014). According to Gonçalves (2007), multicriteria analysis can be performed in the GIS environment using one of the two procedures listed below. 1) Boolean overlap: the restrictive criteria are supported by classification methodologies called Boolean computer science (true, false, binary, or bivalent). In this case, there is no weighting of the inputs by their level of importance; 2) Fuzzy logic: the values of the variables' logical criteria can be any real number between 0, corresponding to the false value, and 1, corresponding to the true value. The values can also arise from applying weights to obtain a weighted average; thus, subjective decision-making decreases and is commonly used to standardise certain factors (FOLLETO, 2016; NUNES, 2018)

3 METHODOLOGICAL PROCEDURES USED: SPATIAL UNITS, VARIABLES, AND PROPOSED INDICATORS

Given this study's purposes, the urban roads of Belo Horizonte, in the central portion of the state of Minas Gerais/Brazil, were used as spatial analysis units (Figure 2) based on the vector base of the municipal road network, created and updated by the Belo Horizonte City Hall's Data Processing Company (Prodabel/PBH). In total, this network is approximately 4,962.5 km long, represented by 52,178 georeferenced vectors, which represent spatial analysis units organised in a database with their respective non-graphical attributes (values in each variable), distributed according to Belo Horizonte's ten Administrative Regions, as shown in Figure 2. The methodological procedures used can be divided into three main stages: 1) variable selection, 2) measurement weighting, and 3) proposition of indicators (disaggregated and the ICV), as depicted in Figure 3. In addition to processing and treating data, the first stage involved the selection of the variables used in this proposal based on the literature review. The selected variables were classified according to the following factors: 1) those concerning the road's general characteristics (Road System); 2) those that identify the presence and characteristics of bicycle infrastructure (Road Infrastructure); and 3) those that characterise the environment where the road

is inserted (Environment). As the subject has no legal or technical normative aspects, variables were selected based on the reflections in the consulted bibliography. The availability of secondary data for analysis was considered since there was no data production by direct research or fieldwork. Seven variables consistent with the local reality were selected to compose the proposed methodology and in line with data availability. It is important to emphasise that data availability for secondary analysis tends to be one of the main limiting aspects of selecting variables.

The variables were weighed using factors obtained through the Delphi Method, a prediction technique designed to provide advanced knowledge of the probability of future events, using the request and systematic collection of expert opinions on a given subject. According to Wright and Giovinazzo (2000), it was initially developed in the 1950s by Rand Corporation/USA to obtain specialist consensus on technological forecasts. In general, the Delphi Method can be defined as an interactive activity designed to bring together the opinions of a group of experts to obtain consensus. It is based on a group communication process to allow individuals to deal with and explore complex problems. In addition to seeking consensus, studies based on this method propose to predict the future based on collecting qualitative/quantitative information based on the knowledge of a specific group of individuals specialised in the topic in question.

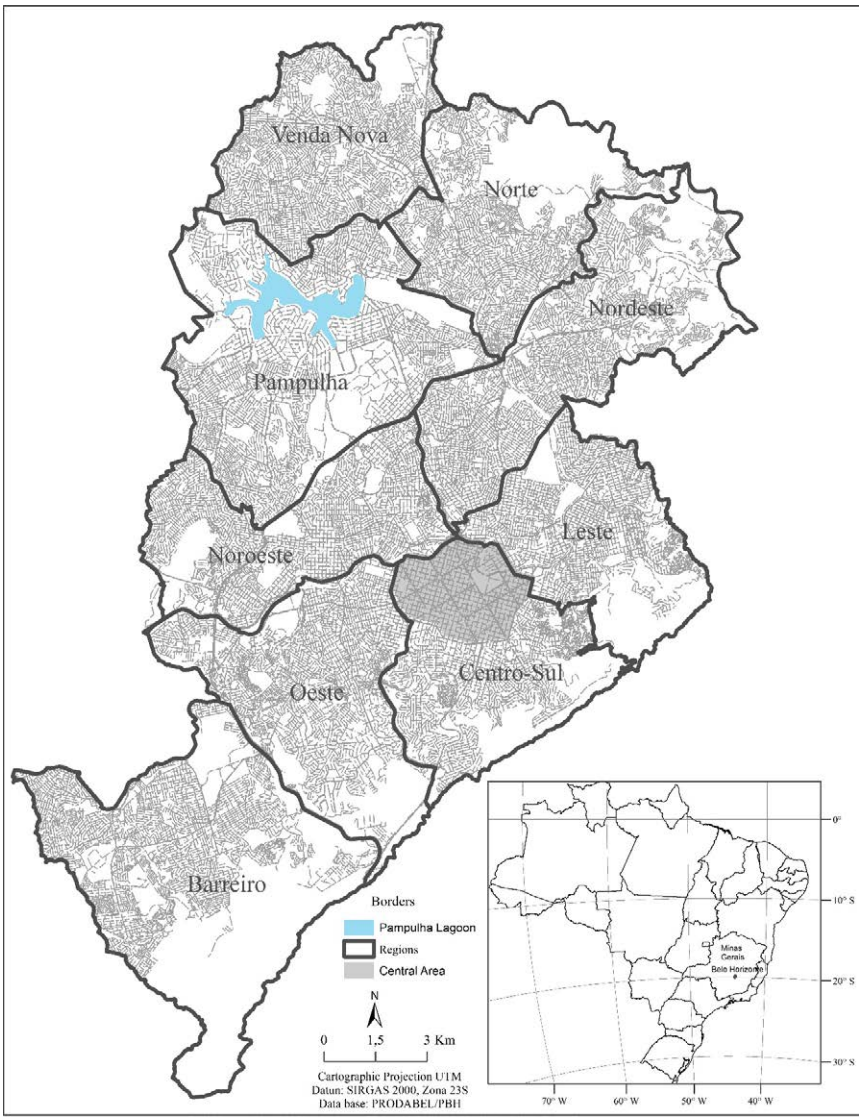


Figure 2 | Road network of Belo Horizonte/Minas Gerais/Brazil

Source: Prodabel/PBH cartographic base (2020).

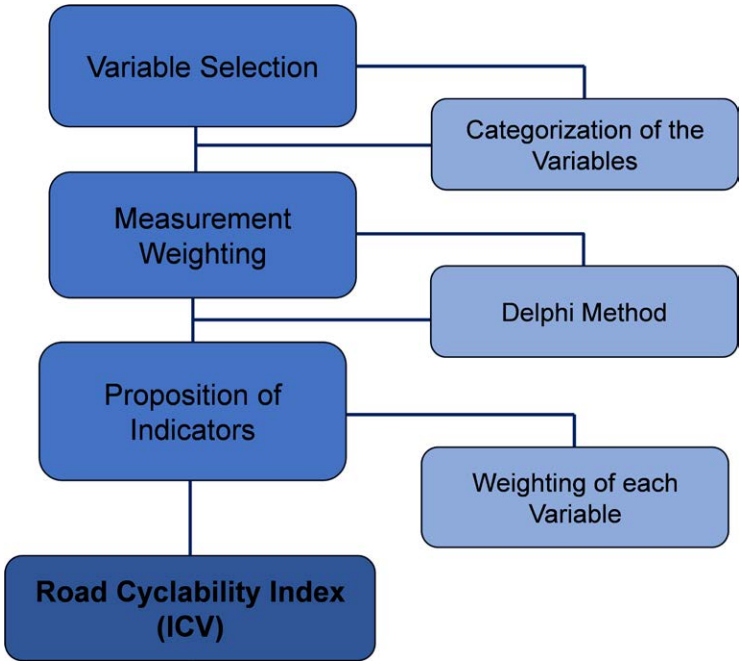


Figure 3 | Methodological Procedures

Source: não tem no documento

In this research, the Delphi method was used to support the definition of the weighting coefficients of the manipulated variables, thus applying the method to obtain coefficients/weights based on the choice of a multidisciplinary group of specialists who are cognizant of the phenomenon and the spatial reality where it is located. Given the established purposes, the selection of specialists aims at a multidisciplinary group with knowledge of the study area for a combined assessment of the road cyclability factors. Those involved represent the municipal public administration, university professors specialising in urban mobility and transport, Ph.D. students in transport, and private sector analysts focused on urban planning. The analysis of the experts' evaluations verified that the variables with the highest scores match those most relevant in the literature analysed. For example, the "Preferential treatment for bicycles" variable concentrated most evaluations in scores 9 and 10. Next was the variable "Efficiency of public lighting," whose evaluation average scored 8.5.

After three rounds of assigning scores, disaggregated and aggregated indicators were proposed, resulting from the combined factors' scores. Equation 1 represents the operation.

$$P = \frac{A}{\mu} \qquad \text{Equation 1}$$

wherein:

P = Weighting of each Variable;

A= Evaluation

μ= Average of the evaluations of all factors.

Table 2 shows the results of the importance coefficients of the variables, which served as the basis for the proposed Road Cyclability Index (ICV). It is an aggregate indicator that summarises the performance of all factors and variables. The sum of the scores of the attributes of the pathways was given, whose weights were fixed by the Delphi Method (Equation 2). Overall, the road segments with the highest results have the best conditions for bicycle use. However, the adequacy and distribution of these

results into classes, understood here as "Very Low," "Low," "High," and "Very High" cyclability, required the use of a specific classification method.

$$ICV = \sum_{n=1}^{7}(D_n P_n)^2 \qquad \text{Equation 2}$$

where:

ICV= Road Cyclability Index;

D= Performance of track attributes;

P= Weighting in each Variable.

A quantiles classification method was used to the detriment of an arbitrary categorisation for mapping purposes. This method creates intervals to equate the distribution, organising them into classes with similar frequencies. As four classes were opted for, the distribution is approximately 25% per class to ensure that each class interval has approximately the same number of values and that the change between the intervals is reasonably consistent. The variables were also classified according to their level of performance for a disaggregated analysis. There are two ways to establish these levels. The first, configuring variables with non-Boolean attributes, inputs performance levels based on a grade or concept. The higher this grade or concept, the better the attribute's performance in the reality in question. The second method arranges the variables with Boolean attributes. In line with the characteristics of a cyclability study, the attribution of performance levels to Boolean attributes starts from the condition of "adequate" or "inadequate." As each factor has specific features closely associated with the reality in which the attribute is inserted, each variable should be evaluated individually to ensure that it receives the most appropriate treatment when assigning performance levels. Thus, the definition of the score varies according to how each attribute relates to the analysed space. In this research, the performance level of each variable varies from 0 (inadequate), 1 (partially adequate), 2 (adequate), and 3 (ideal), as detailed in Figure 4, which discriminates according to the selected factor[2].

Table 2 | Weighting coefficients of the variables used – Delphi method

Factors	*Variables*	*Coefficient*
Road System	Typology (V1)	1,026
	Width (V2)	0.939
	Paving (V3)	0.927
Road Infrastructure	Preferred treatment (V4)	1.310
	Hierarchy (V5)	1.242
	Lighting efficiency (V6)	1,156
Environment	Longitudinal slope (V7)	1.001

Source: Developed by the author.

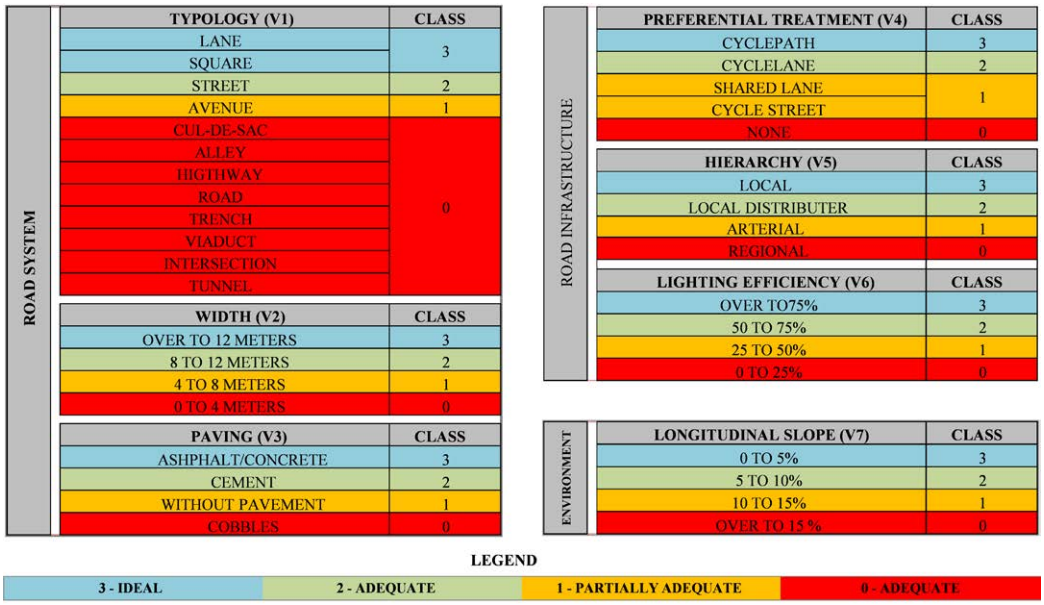


Figure 4 | Categorization of the variables used, according to selected factors and performance level

Source: Developed by the author.

4 CYCLABILITY LEVELS IN BELO HORIZONTE/MG: DESCRIPTION AND ANALYSIS OF THE RESULTS

Notably, there is no clearly defined spatial pattern in Belo Horizonte; thus, it was not possible to define contiguous areas intensely restrictive or appropriate to bicycles as a means of transport. However, as observed and inferred from Figure 5, roads with higher cyclability levels are prevalent in the Pampulha, Centro-Sul, and Venda Nova regions compared to other regions. It is no coincidence that these regions have the most extensive road networks with preferential bicycle treatment. It should also be noted that the Central-South and Pampulha Regions house the higher-income population (FONSECA *et al*., 2017), including higher construction standards, wider roads, and large areas for public leisure, such as the lagoon and public parks where people from around the city gather for physical/sports activities.

The logic of spatial distribution coincides with the different territory use patterns. The road segments with the lowest cycling potential are spatially associated with recently occupied areas, such as the most peripheral areas of the North and Northeast regions. Furthermore, this also applies to sections with steeper inclines, such as those in the south/southeast portion of the municipality, bordered by the Serra do Curral uplands. The precariousness of the available physical infrastructure is striking in the areas associated with shantytowns and favelas. There is a lack of pathways with the higher performance levels required for cyclability. Frequently, routes are hilly alleys, many lacking good paving and efficient public services, such as lighting.

Although roads with preferential treatment for bicycles are expected to have a higher level of cyclability, the proposed methodology revealed several examples of roads with cycling infrastructure where this was not the case. Even though the conditions for bicycle use as a mode of transport are not limited to the available cycling infrastructure, it is clear that the proper implementation of a bicycle transport infrastructure is not inconsequential and directly results in an increase in the perception of comfort and safety for cyclists. However, an inadequate implementation may imply a failure to fulfil the potential to stimulate suitable bicycle transport. Viola *et al*. (2019) use the logistic regression statistical method to propose a model to estimate the potential use of bicycles as a means of transportation in Belo Horizonte. In general, the results, particularly in the city's central region, confirmed the possibilities of

bicycle usage and indicated the positive potential for migration from other modes of transportation, especially motorised individual modes.

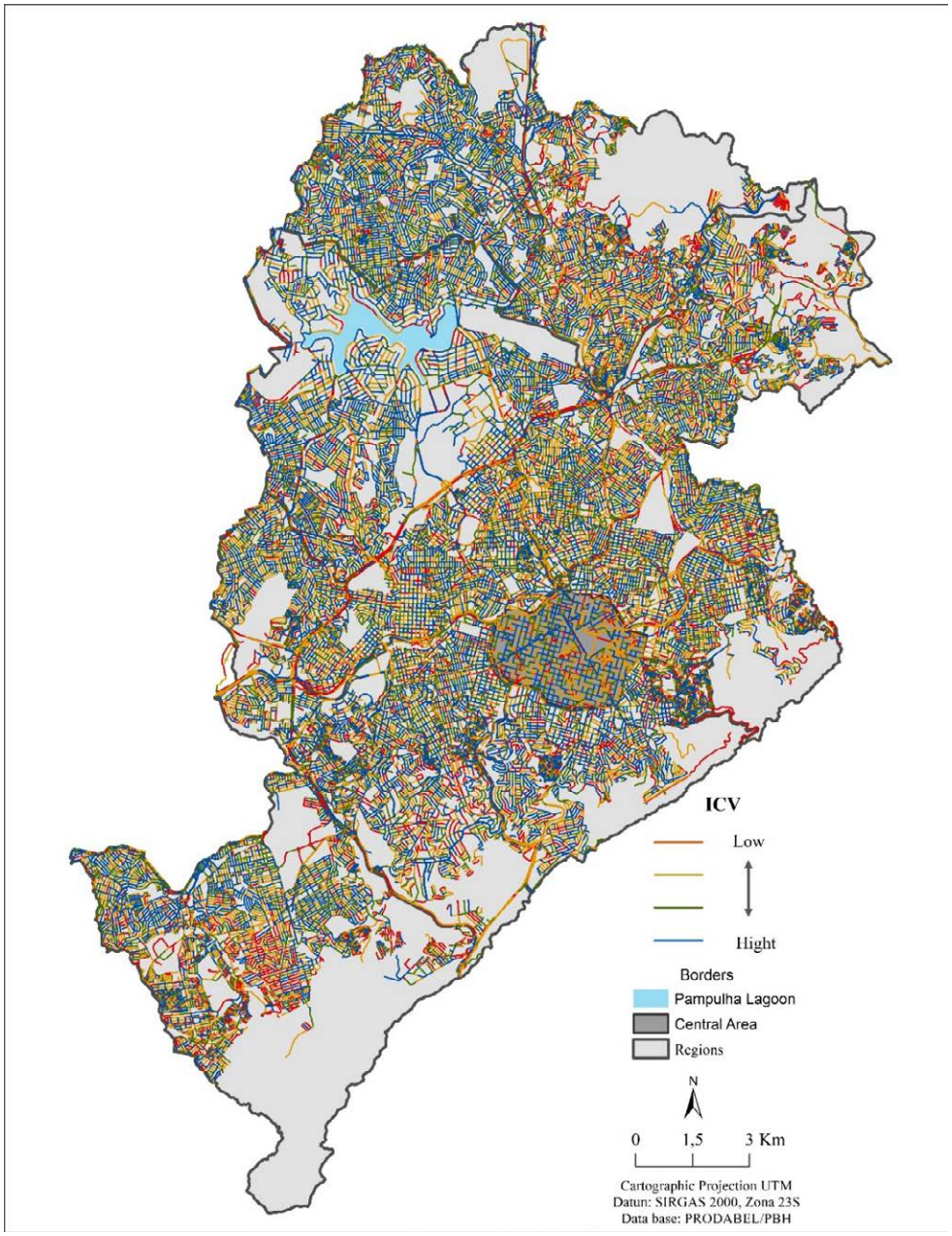
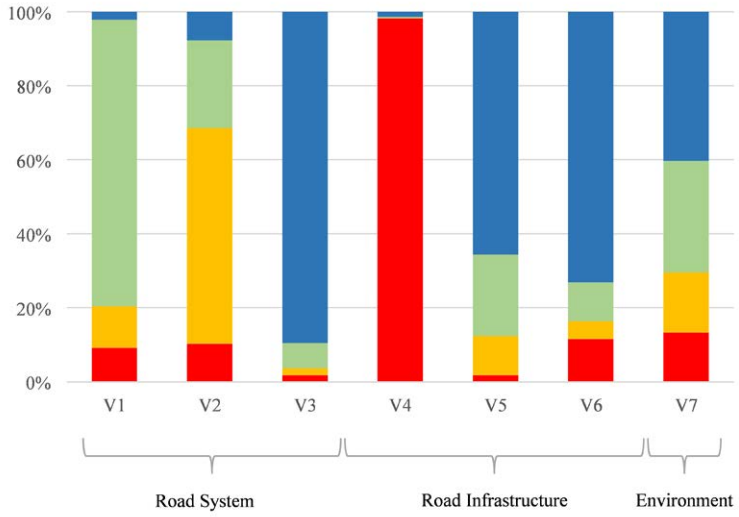


Figure 5 | Road Cyclability Index in the municipality of Belo Horizonte/MG

Source: Developed by the author.

A disaggregated analysis of the results, broken down according to the performance level of each variable (Figure 6), indicates a more favourable situation for bicycle use in the variables road paving (V3) and lighting efficiency (V6). The ideal pathway condition for these two variables corresponded to 89.6% and 85.6%, respectively. The high scores in the variables hierarchy (V5) and road slope (V7) are also noteworthy. In both, the roads' cyclability level exceeds 70%. Declivity also merits highlighting since the myth that the city is unsuitable for cycling is still common, given the supposed prevalence of very steep roads, which does not represent reality. The level of suitability is only reduced in the eastern portions of the Central-South and Eastern Regions, where the Serra da Curral's escarpments form more significant obstacles to bicycle use. The results are less favourable when the preferential treatment

variable (V4) distribution is observed. In this case, 98.1% of the routes were considered inadequate. By superimposing the vectors referring to those routes considered adequate/ideal on the preferential treatment network (bicycle paths/bicycle lanes) in Belo Horizonte, it is possible to identify possible lines of expansion/integration for cycling. In principle, these areas should be considered priorities for public infrastructure investment.



Performane Level (km)				
Variáveis	Inadequado	Parcialmente Adequado	Adequado	Ideal
V1	4.805	5.839	40.431	1.109
V2	5.336	30.435	12.397	4.016
V3	960	941	3.535	46.748
V4	51.210	34	239	701
V5	954	5.503	11.504	34.223
V6	6.027	2.521	5.465	38.171
V7	6.948	8.487	15.725	21.024

Figure 6 | Distribution by Road Cyclability Index variables in the municipality of Belo Horizonte/MG

Source: Developed by the author.

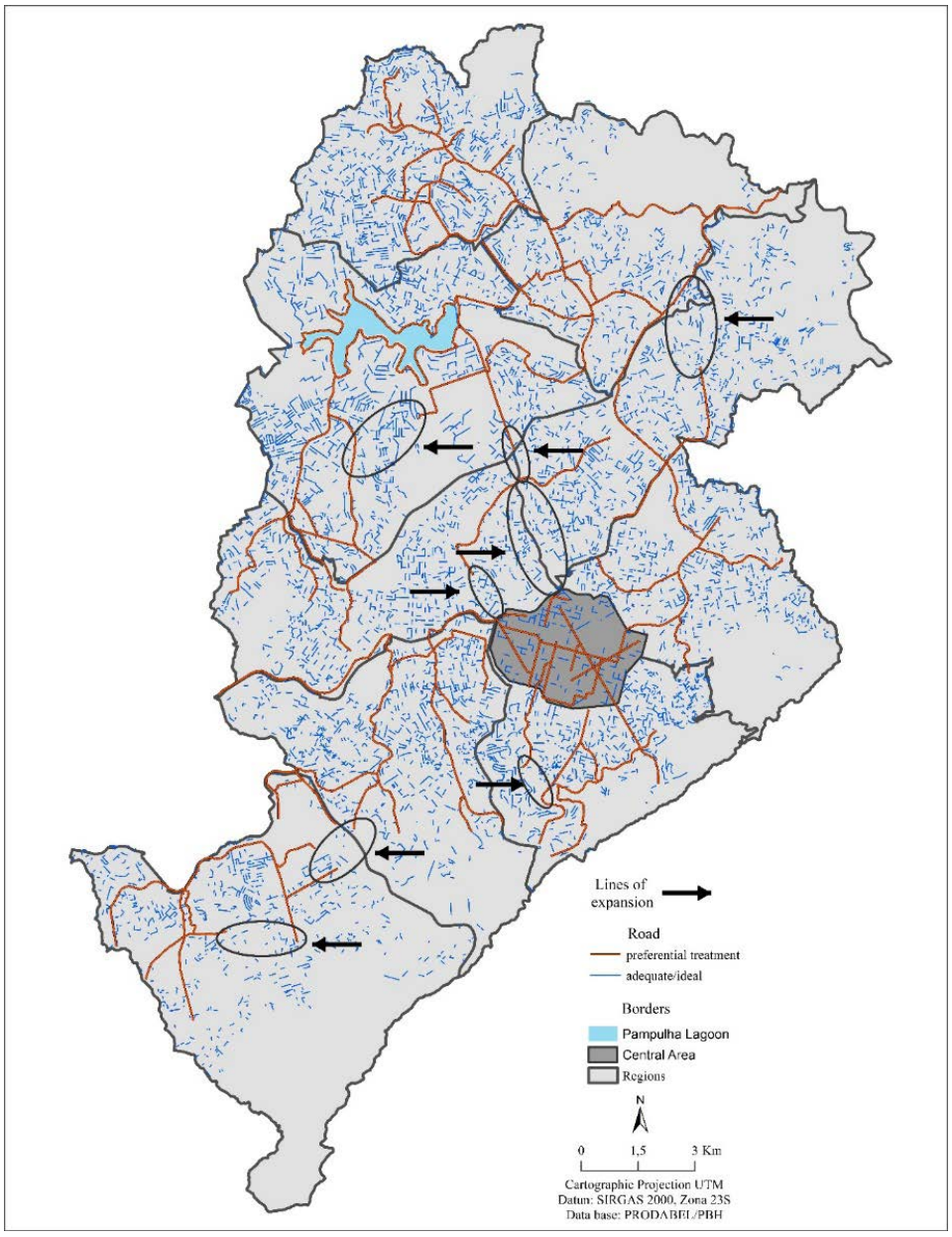


Figure 7 | Road Cyclability Index in the municipality of Belo Horizonte/MG

Source: Developed by the author.

5 FINAL CONSIDERATIONS

After establishing a methodological approach inherent to its purpose, this study estimated the road cyclability level in Belo Horizonte and offered parameters capable of supporting the design of sustainable public transport policies. As it is based on active systems, it applies to the reality of other large Brazilian cities, marked by the high concentration of individual motorised transport. Further theoretical and conceptual progress is required, as this contribution reinforces the need for alternatives to the monolithic view of the city of automobiles and vehicle flow. As described throughout the work, cyclability is an underexplored and relatively recent academic concept. In Brazil, studies of active transportation directly associated with mobility and sustainable accessibility are still infrequent. Thus, this work proposes techniques and methodologies offering cyclability indicators that foster a broader discussion on improving public urban management and planning policies and inducing increasingly sustainable urban mobility.

Overall, the results suggest that a significant portion of the roads in Belo Horizonte (approximately 44.3% of the road extension) have good levels of cyclability. This data contradicts the common-sense view that, given its topography and climate, the municipality is unsuitable for using bicycles as a mode of transport. Belo Horizonte has a very underutilised high cyclable potential, especially if there is an investment in expanding the exclusive/preferred road infrastructure, which is still very incipient in its urban fabric. Moreover, a brief comparison of the spatial distribution of the results shows a substantial imbalance in the availability of accessible cycling systems, with an intense concentration in the Pampulha, Centro-Sul, and Venda Nova regions. On the other hand, the eastern and northern regions had the lowest CVI levels. These units are spatially associated with areas of recent occupation, such as the most peripheral areas of the North region, and areas of steep longitudinal slopes, such as in the East. The results also indicate that the inadequate deployment of cycling infrastructure may result from the failure to exploit the potential to promote adequate bicycle transport. The roads with cycling infrastructure with the most favourable performance levels are enlightening examples.

Even with reservations and careful interpretation, the results and the methodology proposed through the indicators presented can support municipal governments and bodies linked to public transport policies, which have recently tried to increase municipal bicycle use. The cycling routes in Belo Horizonte mentioned above result from these efforts (BELO HORIZONTE, 2018). They are a set of actions under the responsibility of the municipal administration, aiming to meet the aspirations of cyclist organisations and manage the demand for bicycle transportation by creating attractive routes for cycling. Thus, a tool capable of measuring road cyclability levels is an essential input in the execution of the project. At the same time, using indicators that assess the level of cyclability can foster the appropriate targeting of public investments to priority areas and routes, manage demand to increase the number of trips, and establish a balance in the amount of travel generated by modes of transport.

Other paths for future research on cyclability can be recommended, such as studies investigating whether the cyclable routes proposed and implemented by municipal authorities align with local cyclability. Furthermore, other analyses based on primary data, such as ODS 2002 and 2012, would enable confrontations validating the results achieved here. An example could be the simulation of routes from the origins and destinations of trips by the mode in question. In reality, every motorised journey starts with an active mode of transport, such as walking and potentially cycling. Thus, research that helps to encourage bicycle use associated with motorised modes of transport is essential for the understanding and diffusion of bicycles as an effective mode of transport.

NOTES

1| This article is a result of the master's thesis "The Bicycle and Urban Mobility: the effects of the diffusion of the cycle path network on bicycle commuting in Belo Horizonte/MG," defended within the scope of the Graduate Program in Analysis and Modeling of Environmental Systems at IGC/UFMG

2| It is noteworthy that the method used to evaluate performance can be based on interpretations with a certain degree of arbitrariness. However, when recognized in the cited literature, the interpretations suggest the norms/standards used in the aforementioned reference works.

ACKNOWLEDGEMENTS

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REFERENCES

BAROUCHE, T. O. **O caos da mobilidade urbana**: uma análise do atual regime de financiamento do transporte público municipal e a necessidade da construção de novos paradigmas. Publicação do XXIII ENCONTRO NACIONAL DO CONPEDI/UFSC, 2014, p. 404-425.

BOTMA, H. **Method to Determine Level of Service for Bicycle Paths and Pedestrian-Bicycle Paths**. In Transportation Research Record 1502, TRB, National Research Council, Washington, D.C., 1995.

BRASIL. Lei 12.587, de 3 de janeiro de 2012. Institui as diretrizes da Política Nacional de Mobilidade Urbana e dá outras providências. **Diário Oficial da União**, Brasília, 2012.

BUEHLER, R.; DILL, J. Bikeway networks: a review of effects on cycling. **Transport Reviews**, 2016, p. 1-19. Available at: https://doi.org/10.1080/01441647.2015.1069908

CARDOSO, L. **Transporte público, acessibilidade urbana e desigualdades socioespaciais na Região Metropolitana de Belo Horizonte** (Tese de Doutorado) – Instituto de Geociências, Universidade Federal de Minas Gerais, Belo Horizonte, 2007.

DAVIS, J. **Bicycle Safety Evaluation**. Auburn University, City of Chattanooga, and Chattanooga–Hamilton County Regional Planning Commission, Chattanooga, Tenn, 1987.

DILL, J.; CARR, T. **Bicycle Commuting and Facilities in Major US Cities**: if you build them, commuters will use them – Another Look, Washington, DC: Transportation Research Board, 2003.

DIXON, L. B. B**icycle and Pedestrian Level-of-Service Performance Measures and Standards for Congestion Management Systems**. In Transportation Research Record 1538, TRB, National Research Council, Washington, D.C, 1996. Available at: https://doi.org/10.1177/0361198196153800101

DOWLING, R. G. *et al*. **Report 616**: multimodal level of service analysis for urban streets multimodal level of service analysis for urban streets. Transportation Research Board of the National Academies, Washington, D.C, 2008.

ELIOU, N.; GALANIS, A.; PROIOS, A. **Evaluation of the bikeability of a Greek city**: case study "city of volos". Wseas Transactions on Environment and Development, v. 5, n. 8, 2009, p. 545–555.

FHWA. **Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes**. Federal Highway Administration, US Department of Transportation McLean, VA, 2002.

FONSECA, D. F.; LOBO, C.; GARCIA, R. A. Imposto predial e territorial urbano: uma metodologia de ajuste tributário para Belo Horizonte/MG. **Urbe. Revista Brasileira de Gestão Urbana**, v. 9, p. 513-526, 2017. Available at: https://doi.org/10.1590/2175-3369.009.003.AO10

FORESTER, J. **Effective cycling**, 6th ed. The MIT Press, Cambridge, 1993.

FULLER, D. *et al*. Impact Evaluation of a Public Bicycle Share Program on Cycling: a case example of BIXI in Montreal, Quebec. **American Journal of Public Health**, v. 103, n. 3, e85–e92, 2013. Available at: https://doi.org/10.2105/AJPH.2012.300917

HANSEN, W. G. **Accessibility and residential growth**. Diss. Massachusetts Institute of Technology, 1959.

JENSEN, S. Pedestrian and Bicyclist Level of Service on Roadway Segments. In Transportation Research Record. **Journal of the Transportation Research Board**, N.. 2031. Transportation Research Board of the National Academies, Washington, D.C, 2007. Available at: https://doi.org/10.3141/2031-06

JONES, S. R. **Accessibility measures**: a literature review. Transport and Road Research Laboratory. Laboratory Report 967, 1981.

KRENN, P. J.; OJA, P.; TITZE, S. Development of a Bikeability Index to assess the bicycle friendliness of urban environments. **Open J. Civil Eng**. v. 5, 2015, p. 451–459. Available at: https://doi.org/10.4236/ojce.2015.54045

LANDIS, B. W. **Bicycle Interaction Hazard Score**: a theoretical model. In Transportation Research Record 1438, TRB, National Research Council, Washington, D.C, 1994.

LESSA, D. A. *et al*. Accessibility and urban mobility by bus in Belo Horizonte/Minas Gerais - Brazil. **Journal of Transport Geography**, v. 77, 2019, p. 1-10. Available at: https://doi.org/10.1016/j.jtrangeo.2019.04.004

LOTT, D. Y.; TARRDIFF, T.; LOTT, D. F. Bicycle Transportation for Downtown Work Tripes: a case study in Davis, California. Transportation, Research Record: **Jornal of the Transportation**, Washington, DC, 1977.

MANUM, B. *et al*. **Modelling Bikeability**: space syntax based measures applied in examining speeds and flows of bicycling in Gothenburg. Proceedings of the 11th Space Syntax Symposium, 2017.

MARTENS, K. **The bicycle as a feedering mode**: experiences from three European countries. Transportation Research. Part D, 2004, p. 281-294. Available at: https://doi.org/10.1016/j.trd.2004.02.005

NIELSEN, T. A. S.; SKOV-PETERSEN, H. Bikeability – Urban structures supporting cycling. Effects of local, urban and regional scale urban form factors on cycling from home and workplace locations in Denmark. **Journal of Transport Geography**, 2018, p. 36-44. Available at: https://doi.org/10.1016/j.jtrangeo.2018.04.015

NOBREGA, R. A. A. **Mapa de declividade da malha viária de Belo Horizonte**. 2016.

NORDSTRÖM, T.; MANUM, B. **Measuring bikeability**: space syntax based methods applied in planning for improved conditions for bicycling in Oslo. In: Proceedings of the 10th International Space Syntax Symposium, 2015.

PEREIRA, R. *et al*. **O uso da sintaxe espacial na análise do desempenho do transporte urbano**: limites e potencialidades. Texto para Discussão, n. 1630. Rio de Janeiro: Ipea, 130, 2011.

PEZZUTO, C.; SANCHES, S. Identificação dos fatores que influenciam o uso da bicicleta, visando ao direcionamento de programas cicloviários. **Revista dos Transportes Públicos** – ANTP, Ano 25, 2003.

PUCHER, J.; BUEHLER, R. Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. **Transport Reviews**, v. 28, n. 4, 2008, p. 495–528. Available at: https://doi.org/10.1080/01441640701806612

RIETVELD, P.; DANIEL, V. Determinants of bicycle use: do municipal policies matter? **Transp. Res**. Part. A Policy. Pract., v. 38, 2004, p. 531–550. Available at: https://doi.org/10.1016/j.tra.2004.05.003

RYBARCZYK, G.; WU, C. Bicycle facility planning using GIS and multi-criteria decision analysis. **Applied Geography**, v. 30, n. 2, 2010, p. 282–293. Available at: https://doi.org/10.1016/j.apgeog.2009.08.005

SENER, I.; ELURU, N.; BHAT, C. Who Are Bicyclists? Why and How Much Are They Bicycling? **Transportation research record**, v. 2134, 2009, p. 63–72. Available at: https://doi.org/10.3141/2134-08

SISSON, S. B. *et al*. Suitability of Commuting by Bicycle to Arizona Elementary Schools. **American Journal of Health Promotion**, v. 20, n. 3, 2006, p. 210–213. Available at: https://doi.org/10.4278/0890-1171-20.3.210

SORTON, A.; WALSH, T. **Bicycle Stress Level as a Tool to Evaluate Urban and Suburban Bicycle Compatibility**. In Transportation Research Record 1438, TRB, National Research Council, Washington, D.C, 1994.

SOUZA, P. B. **Análise dos fatores que influenciam o uso da bicicleta para fins de planejamento cicloviário**. Tese apresentada à Escola de Engenharia da Universidade de São Carlos, 2012.

SZYSZKOWICZ, S. S. **Bikeability as an Indicator of Urban Mobility**. Economic Analysis Directorate Transport Canada Place de Ville, Tower C Ottawa, 2018.

TRALHÃO, L. *et al*. **Metodologia em ambiente SIG para localizar dispositivos de auxílio ao ciclista em cidades declivosas**. Presented at the 2015. Coimbra, 2015.

TURNER, S.; SHAFER, S.; STEWART, W. **Bicycle Suitability Criteria for State Roadways in Texas**. Texas Transportation Institute, Texas A&M University System, College Station, 2012.

VASCONCELLOS, E. A. **Transporte urbano, espaço e equidade**. São Paulo: Fapesp, 1996.

VIOLA, P. D. *et al*. Potencial de viagens por bicicleta em Belo Horizonte: uma proposta metodológica com base na Pesquisa Origem e Destino de 2012. **Revista Transporte y Territorio**, n. 20, p. 370-386, 2019. Available at: https://doi.org/10.34096/rtt.i20.6397

WAHLGREN, L. **Exploring bikeability in a metropolitan setting**: stimulating and hindering factors in commuting route environments. School of Health and Medical Sciences: Örebro University, 2011. Available at: https://doi.org/10.1186/1471-2458-12-168

WINTERS, M. Mapping bikeability: a spatial tool to support sustainable travel. **Environment and Planning B: Planning and Design**, v. 40, 2013, p. 865 – 883. Available at: https://doi.org/10.1068/b38185

Understanding agroecological livestock paths in northern Uruguay

Comprender los caminos agroecológicos de la ganadería en el norte de Uruguay

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ABSTRACT

Agroecology is emerging in Uruguay as an alternative production model. Understanding and interpreting the vision of farmers and rural technicians on the agroecological transition processes in the country is a challenge for research. The main hypothesis that motivated this study is that the views of producers and technicians on agroecology guide, frame, and structure the transition processes. This article presents the results of two focus groups carried out in 2020 with professionals from different institutions and family livestock farmers in the north of the country. They show the great diversity of visions and the different paths taken by farmers. Despite these different visions, some common ideas could contribute to defining an agroecological livestock farming model. These paths permit suggesting and evaluating differentiated proposals for developing agroecological family farming.

Keywords: Family farming. Agroecology. Focus groups. Socio-technical practices.

RESUMO

A agroecologia está surgindo no Uruguai como um modelo alternativo de produção. Compreender e interpretar a visão de agricultores e técnicos rurais sobre os processos de transição agroecológica no país é um desafio para a pesquisa. A principal hipótese que motivou este estudo é que as visões de

produtores e técnicos sobre agroecologia orientam, enquadram e estruturam os processos de transição. Este artigo apresenta os resultados de dois grupos focais realizados em 2020 com profissionais de diferentes instituições e pecuaristas familiares do norte do país. Eles mostram a grande diversidade de visões e os diferentes caminhos percorridos pelos agricultores. Apesar dessas visões diferentes, algumas ideias comuns podem contribuir para a definição de um modelo agroecológico de pecuária. Esses caminhos permitem sugerir e avaliar propostas diferenciadas para o desenvolvimento da agricultura familiar agroecológica.

Palavras-chave: Agricultura familiar. Agroecologia. Grupos de foco. Práticas sociotécnicas

1 INTRODUCTION

Agroecology is an incipient alternative production model to Uruguay's current product-oriented dominant model. According to Altieri and Toledo, an alternative production model is understood as one that promotes national and local food production by family farms (and urban production systems) based on innovation, local resources and the use of alternative energies, such as solar energy (ALTIERI; TOLEDO, 2011). Since the approval of the National Plan on Production with Agroecological Bases (ANP), agroecology has begun to be implemented as a public policy (GAZZANO *et al*., 2020). The ANP declares of national interest, "the promotion and development of production systems, distribution and consumption of agroecological-based products, both in their natural and processed state, aiming to strengthen food sovereignty and security, contributing to the environment care, in order to generate benefits that improve the life quality of the Republic inhabitants." (LAW 19.717/2019 Art. 1).

In addition, it declares family farmers and urban and suburban agricultural production systems as the main collective subjects of agroecological-based production systems. Besides, the Ministry of Livestock, Agriculture and Fisheries (MGAP, Ministerio de Ganadería, Agricultura y Pesca) recently called on agricultural production organisations to submit agroecological transition proposals (AT) through the "Agroecological Path" call1. This constitutes a propitious scenario to imagine new sustainable production systems based on biodiversity and respect for natural resources (GAZZANO *et al*., 2020; POSADA RODRÍGUEZ *et al*., 2020). In this context, understanding and interpreting the views of producers and agricultural technicians on AT processes in the territory is a challenge for this research, organisations and the State.

It is then a matter of moving towards a new situation, where the dominant productive model comes into discussion. Moving towards an agroecological production model would allow responding to the deterioration produced by the dominant socio-technical regime, which seems necessary and urgent (TITTONELL, 2019). Although research on family livestock systems in Uruguay has analysed their social, economic and ecological sustainability (ALBICETTE *et al*., 2016; GAZZANO; GÓMEZ, 2017; MODERNEL *et al*., 2018), not much research has been interested in studying these systems from an agroecological perspective, analysing the AT dynamics of Uruguayan livestock family producers (LFP) at a livestock production level. Some studies point to the need to better understand the management and conservation of the Natural Field (NF) carried out by LFP and, thus, generate changes through collaborative work between technicians and family producers (ALBICETTE *et al*., 2016; DIÉGUEZ, 2014).

On the other hand, the country's beef exports have allowed it to access, through innovations and differentiation strategies, specialised niches of the high-quality meat market (PAOLINO *et al*., 2014). Since livestock contributes approximately 40% of agricultural GDP (MGAP, 2021), the challenges of AT are even greater. The extensive livestock production system on natural field (NF) (predominant) began more than four hundred years ago with the introduction of livestock to the Pampas region of the Río de la Plata, giving rise to what was called Uruguay Pastoril (DOTTA *et al*., 1972). This production system also determined the strong presence of a traditional type of LFP (family farmers) in the country, mainly dedicated to livestock breeding (RIBEIRO, 2009). These LFPs can be considered

a special type of family farmer, especially "breeders", dedicated to mixed bovine and ovine breeding, which do not include agriculture or beef finishing processes (ROSSI *et al*., 2019). The advance of agricultural intensification processes led to the fact that today livestock farming competes for using natural resources with agriculture and forestry in the country (GAZZANO; ACHKAR, 2016). Between 2000 and 2011, the area of agricultural and forestry regions increased by 110% and 158%, respectively, while livestock decreased by 36% (MGAP DIEA, 2021). Even despite the evident progress of the intensive agriculture and forestry model promoted by agribusiness (GUIBERT *et al*., 2011), according to the last General Agricultural Census, most of the area exploited in the country (39%) corresponds to livestock over NF (MGAP DIEA, 2014).

Regarding social stratification, there are 21,657 family farms in the country (MGAP DIEA, 2021), representing almost half the total number of farms compared to 2011. 65.4% of family producers declare cattle (meat or milk) or sheep (meat and wool) as their main production; most of them are based on NF (MGAP DIEA, 2021). Family lifestyle and their relationship with nature and the landscape are characteristic of a "gaucha" culture and tradition that prevail in decision-making in the Pampas region (RIBEIRO, 2009). They are families with low relative incomes, mainly due to their small scale, lifestyle and work, which determine the use of the family labour force and low technology incorporation based on inputs (DOGLIOTTI *et al*., 2020). These livestock families persist and are grouped into grassroots organisations in the territory, developing individual and collective resistance to the advance of agribusiness, such as sectoral demands for land access policies and training and technical advice support (DÍAZ, 2021; ROSSI *et al*., 2019).

Therefore, agricultural institutions have generated calls and projects in which technicians have been hired to work with family producer organisations. Among these calls, institutional strengthening, the promotion of technologies for family production and those aimed at women and young people were important (FRANCO *et al*., 2016). Although, in many cases, these calls have reinforced technical assistance to LPFs and their organisations in the study area, strengthening family production involves advising, understanding, and respecting the singularities that underlie production systems, and even more so from an AT perspective.

The study's objective was to understand and interpret the vision that producers and technicians have about AT in the livestock territory of the north of the country, particularly discussing what the different actors understand about it and agroecology. Within this framework, it is assumed that the (re)construction of the agroecological family livestock production system will depend on its situation, objectives and the producers' vision of agroecology; therefore, this will guide the transition process. In this way, it is intended to contribute to the understanding of the role of public and private institutions and LFP organisations in the transition toward an agroecological production model.

The article is divided into four sections. The first section presents the conceptual theoretical framework. The second presents the methodology used. The results are presented in the third section, along with the development of the participants' perspective in the discussion groups on agroecology and AT and the analysis matrix that allowed us to interpret the different proposals or AT paths. Finally, based on the different visions and proposals of AT identified, we reflect on how the northern LFP move towards an agroecological production model.

2 AGROECOLOGICAL TRANSITION: MULTIPLE PATHS

The transition is not a recent issue. In the 1980s, Stuart Hill proposed redesigning production systems, highlighting the importance of profoundly transforming from conventional to organic agriculture. Although an AT was not specifically defined, the main relevance was placed on the human-nature relationship and the importance of the efficiency of chemical inputs use and change to organic inputs use (HILL, 1985).

In this sense, Gliessman (1998) mentions a series of necessary levels to move towards agroecology, which support the redesign of agricultural exploitation and the relationship between different actors (producers and consumers). Thus, we are approaching a construction thinking that starts from the individual but includes multilinear and scalar changes (ELZEN *et al*., 2017).

In this study, AT is understood as a process of deconstruction/construction at the individual level, on farms, and collectively in the territory, which responds to the challenge of implementing processes of conception, selection and dissemination of innovations for an agroecological transformation (VITRY; CHIA, 2016). From this perspective, territories become devices where producers and technicians experience new practices, alliances and relationships (CHIA, 2018). The territory is key in the definition of what should be done to achieve agroecological production systems since it involves cultural aspects, identity and symbolic control over space (HAESBAERT, 1997).

The AT process is understood as socio-technical and organisational innovations and changes, a product of the interaction of multiple actors at different scales (local, national, regional), which brings into play multiple-dimensions phenomena (physical, political, technical, social, financial, and scientific). The aforementioned enables considering AT processes as complex and uncertain situations (CHIA, 2018). During this AT process, actors play an important role in the territory transformation through driving forces (MIER Y TERÁN *et al*., 2018; TITTONELL, 2019), which allow changes and innovations. However, these are not linear but occur as a process of deconstruction/(re)construction produced by local actors in dynamic two-way processes of translations and multiple alliances where producers, extensionists and researchers come together to co-conceive innovations, implement them and evaluate them. This is what Geels (2002), in his theoretical proposal to analyse socio-technical transitions, calls niche innovations (changes and practices at the level of units and localities).

According to Geels (2002), transitions would result (i) from changes at the level of sociotechnical landscapes through national laws or programs that will modify relations at the level of sociotechnical regimes and favour some niche innovations; (ii) from changes in sociotechnical regimes that will determine changes in the landscape and innovation niches. To generate changes in socio-technical regimes, it is necessary that the actions decided in the socio-technical landscape and the actions carried out in the niches occur to modify the relationships between the different components of the socio-technical regime and (iii) due to the appearance of niche innovations, the product of new individual practices or small groups that will gradually modify the socio-technical regime by modifying the relationships and projects of the institutions. Thus, niche innovations generate new paths to move towards another way of producing or production mode.

In agroecology, the transition is seen as a set of processes, of simultaneous paths at different scales, levels and dimensions, where transformations at the level of trophic structures of soil communities and of the rural family with their roles and responsibilities (CLAVEIROLE, 2016; TITTONELL, 2019) are combined with those transformations at the socio-technical, political and cultural level in the territories (CLAVEIROLE, 2016; MIER Y TERAN *et al*., 2018). Agroecology does not yet have a unanimous definition (ALTIERI, 2002), which makes it challenging to study, but at the same time, this non-consensus makes it potentially more interesting because it allows exploring it from different angles.

Among the theoretical debates on ecological modernisation, two forms of agroecology are mentioned (DURU *et al*., 2014; HORLINGS; MARSDEN, 2011). The "weak" refers to a type of modernisation where good management practices are applied to improve the efficiency of external inputs and reduce environmental impacts. The "strong" form of agroecology corresponds to a paradigm shift, which seeks to replace classical inputs (chemical synthesis) with the use of the biological diversity of agroecosystems. It also seeks a new "design" of production systems based on the complementarity between productions.

As an example of the first form, the sustainable intensification proposal implies a gradual improvement process of the ecological efficiency of agricultural systems through innovation in order to tend to greater or equal productivity and profitability with less environmental impact on the maintenance and/or improvement of natural resources, reducing dependence on external inputs (HLPE, 2019). Alonso-Fradejas *et al*. (2020) say these measures reduce environmental problems. However, negative effects still occur since it is an approach aimed at maintaining the established order of agri-food capital and simultaneously incorporates discourses, practices and processes typical of an agroecological approach. For the second form, a systemic approach that aims at the (re)conception and co-conception of agricultural systems through the mobilisation of biodiversity is required (DURU *et al*., 2014). This form is more complex since it is necessary to review the management models of farms, social and rural organisations and resources in a territory, all accompanied by public policies that support this transition (DURU *et al*., 2014; HORLINGS; MARSDEN, 2011).

These are individual and collective changes that involve multiple innovations at different levels. Niche innovations (GEELS, 2002; TITTONELL, 2019) require new coordination capacities between actors and specific learning, such as systemic thinking, organisational dynamics, and knowledge hybridisation (VITRY; CHIA, 2016). Due to the complexity of changes at all levels, there may be several paths in the transition, according to the characteristics of productive models and innovations, and therefore, these paths may more or less bring productive systems closer to being agroecological. This research also aims to contribute to documenting this controversy between weak and strong agroecology to better understand how complex agroecology is.

3 METHODOLOGY: A COMPREHENSIVE APPROACH TO AGROECOLOGY

The research was conducted in Salto and Tacuarembó (northern Uruguay), characterised by extensive cattle ranching on NF (MGAP DIEA, 2021). The methodology used was the discussion groups (DG), which responds to the qualitative research approach of a comprehensive type and was selected to facilitate an approach to the actors' point of view. The use of this technique was justified with the idea that what is said individually is different from what is said in a group (COMPAGNONE; SIGWALT, 2021) since the group generates a feeling of belonging that contributes to the security of sharing information (ONWUEGBUZIE *et al*., 2011). In addition, the technique allows quick and efficient data generation (KRUEGER; CASEY, 2000).

Participant selection criteria were based on information that emerged from two exploratory interviews conducted with qualified informants from the region who carried out a development of the present institutionality and the development of innovations of interest to study MT in livestock, such as the control of the grazing load according to the availability of dry matter in NC and the use of biological control of ticks with native entomopathogens.

Two DG were carried out. One was composed of 10 agricultural professionals who belonged to the public and/or private institutions present in the region and were linked to rural organisations through program-projects or linked as private technical advisors. The other DG comprised seven LFPs linked to social-rural organisations in the region and were involved in programs with some of the process technologies that were defined as of interest for research. According to Onwuegbuzie *et al*. (2011), the DGs were formed between 6 and 12 participants to generate diverse information within the group without inhibiting the exchange of different opinions, experiences or beliefs.

Each DG took half a day of work, and their specific objectives were to explore the vision of the technicians/producers and their institutions/organisations regarding agroecology and AT, to understand the role that institutions/organisations are playing in the implementation of innovations (changes in the management practices and process technologies) and what they imagine the action strategies for an agroecological transition will be. In both groups, individual work and group workshops were combined with sharing and plenary discussion.

4 RESULTS AND DISCUSSION: MULTIPLE VISIONS AND PATHS

4.1 TECHNICIAN DISCUSSION GROUP

There was agreement on the need to reconstruct, at the territorial level, what is thought about agroecology in interaction with agricultural institutions and with the professionals who work in it, taking advantage of collective actions to identify key drivers of changes or innovations.

Some limitations were identified within the institutions to promote AT, where "the institutions' own mandates stand out since there is no clear definition of agroecology". The participants consider that it is more by omission than by opposition to agroecology, although they agreed that the idea is that agroecology "is for hippies [...] utopian, difficult to achieve" and that some referents of the institutions "downplay the importance of agroecology, and even make fun of certain management practices such as Voisin grazing, and that has a tremendous impact on producers." In any case, "there is a vision of promotion, dissemination of ecological alternatives for life and production, based on the fact that society needs to know what is up for change, co-innovate, create, alternatives and change".

The role of some projects that contributed to discussing ways of producing was highlighted, such as those of the Program "More Technology for Family Production"2, which promoted more careful management alternatives with the environment under the modality of research-action-participation, where the joint work between institutions and organisations was key. The cognitive role and the need to innovate in the way of thinking about livestock production were problematised. Will is necessary to generate "a change in consciousness" for technicians "wanting to change and make the decision" is put first to start the path of AT. Contrary to what might be expected, the DG of professionals did not emphasise the need for transformations/innovations for AT from a technical-productive dimension. Instead, it prioritised the cognitive dimension (the will to change) and the role of projects as drivers of innovations from the institutional, although not necessarily linked to a transformative vision of the production mode.

4.2 LFP DISCUSSION GROUP

There was agreement on the need for their organisations to discuss the concept of agroecology and what they understand by TA, highlighting as the main instrument the peer dialogue and maintaining the support of the institutionality present in the territory (through technical, social and productive accompaniment) in the processes of change. In this regard, farmers highlighted that the projects that "landed" in the area provided technical, social and productive advice support and enabled access to different types of training, from how to form a group to sheep and beef health courses. Thus, it was worth noticing that "since the organisation of the area, we have had many possibilities for growth, for the technicians to train us, for the SUL, the INIA, the IPA3 to come, all with different projects or informative talks [...]". It is necessary "among all [...] to make our voices heard because we need things, learning and technicians to support us. We are willing to change, we are!"

This DG's perceptions of agroecology are based, above all, on how they relate to nature, the environment and how they produce. The reflections cover the environmental and productive dimensions, leaving aside group work's social and cultural dimensions. The producers stated that agroecology "means taking care of the environment in general and not depending on chemicals", "preserving the "countryside" in an ecological way, avoiding the use of agrochemicals, because a similar result can be achieved ecologically", or "The most natural and the least harmful way to the development of production, to obtain a healthier diet and the well-being of the environment".

For this DG, agroecology is not yet associated with a comprehensive way of producing, marketing, relating and living. However, many issues from work in their organisations finally lead them to reflect and imagine from other dimensions that are part of integral thinking associated with agroecology, especially when it comes to changes and innovations that make them move towards other models of production and life. In addition, in this situation of redefinition for LFP, the role of organisations as promoters of these changes appears since the organisation structures their position towards innovation differently, not only because access to information and different projects increases but because peer-to-peer communication is enriched.

4.3 COMMON VIEWS

The role of institutions and organisations in proposing changes in the region, building identity and generating collective actions was highlighted. This construction of collective identity defines the socio-technical framework for actions that deconstruct ways of producing, living, and reconstructing others.

The importance of experiencing situations that force "clicking", which operate as key drivers on the path to AT (MIER Y TERAN *et al*., 2018; TITTONELL, 2019) was highlighted. These key drivers in a territory can act interrelated or not, even being linked to a certain crisis which drives to seek alternatives through social and/or rural organisations, opportunities through public policies or other territorial devices, such as precautionary measures for the protection of a basin.

Among the professionals, the "undisputed role of organisations in the construction" of agroecological systems was mentioned as the "importance of a collective and not individual construction",; while among the producers, the importance of reaching "from organisations and institutions to those people in the rural environment" who above all are open "to dialogue between peers" was highlighted, since "the producer used to be individualist, but now it points to the collective; before, the producer was "I"... there are still some, but now we are "we".

In general, the necessary changes to imagine a livestock transition to agroecology discussed in the DG referred to innovations in management practices promoted by the organisations through talks, training and projects that reach rural organisations and where technicians participate as part of the institutionality in the territory. In this sense, the frame is an interesting one since AT always begins with changes in the management practices of a productive system, although ideally, it is considered that it should begin with a redesign of the agroecosystem, with the consequent change in management practices (TITTONELL, 2019). They are ways of producing positioned in intermediate phases between weak and strong agroecology. This must also be considered because AT, seen as a process of change towards a different mode of production, depends on the territory specificities, not only biophysical but also economic, social and institutional.

4.4 ANALYSIS MATRIX FOR AGROECOLOGICAL TRANSITION

To understand and analyse the diversity of opinions and points of view of the technicians and LFP, an analytical matrix facilitated the understanding and interpretation of the DG results in answering the following question: where is it going?

The matrix was designed considering the theoretical framework of Geels (2002) to analyse socio-technical transitions, in this case, transitions towards agroecology. Geels proposes to identify three levels of action, (i) the sociotechnical landscape, in this case, marked by the PNA and the Agroecological Path call in livestock production in northern Uruguay; (ii) the sociotechnical regimes, configured in the relationship between public and private institutions and the LFP in the different production paradigms; (iii) the niche innovations, defined by changes in practices such as in this case the use of bioinsecticide for ticks, or the adjustment of load by measuring grass height.

Considering family farming in northern Uruguay, the horizontal axis in Figure 1 represents the trajectory of AT between two production paradigms or models, from productivist agriculture to agroecological agriculture. The vertical axis also represents the action levels of the innovations involved in AT, defining the extremes from the individual to the collective level. The crossing of these two axes produces four quadrants: three represent situations in which innovations are developed in livestock farming in northern Uruguay (quadrants 1, 2 and 3), and one represents the situation of agroecology as an ideal situation to be achieved by AT (Quadrant 4).

Within each quadrant, the characteristics associated with AT paths are described according to four variables, (i) technical objectives: aspects of production are visualised; (ii) marketing: the marketing channels associated with each form of production are observed; (iii) territory: it is the relationship of the actors with the territory; (iv) coordination: it is the relationship of the actors with the other levels (institutions, organisations, markets).

Collective Level

Productivist agriculture		Agroecological agriculture
Quadrant 1		**Quadrant 4**
Objective: sustainable intensification (increase in productivity per hectare), reducing external inputs		**Objective:** change productive paradigm, redesign of productive systems
Marketing: internal and external market		**Marketing:** short circuits
Territory: support of production and collective relations		**Territory:** it is an organised whole
Actors coordination: Market Oriented		**Actors coordination**: through common projects of the organisations
Quadrant 2		**Quadrant 3**
Objective: sustainable intensification (increase in productivity per hectare) and single production.		**Objective:** niche innovations that introduce changes in the socio-technical regime: (native bioinsecticide for ticks, animal load management).
Marketing: external market		**Marketing:** internal market
Territory: inclusion of producers in agri-food value chains		**Territory:** incipient focused experiences
Actors Coordination: Across Industry/Certification		**Actors coordination**: based on individual and group experiences

Individual Level

Figure 1 | Analysis matrix of the different agroecological transitions for Uruguayan livestock

Source: Prepared by the author.

From this logic, Quadrants 1 and 2 correspond to two AT situations that we can consider closer to the current paradigm of productivist agriculture. In Quadrant 1, collective innovations predominate, which we refer to as "regenerative agroecology". In Quadrant 2, innovations of the property type or "behind the gates" predominate and we refer to them as "industrial agroecology". Quadrants 3 and 4 are situations closer to the agroecological paradigm, and the location between the upper and lower

quadrants depends on the type of innovations and relationships with the territory. The study shows some niche innovations that can be located in Quadrant 3, being "seeds" that can "germinate" in the territories to reach strong agroecology situations in the future. This quadrant was called "agroecology in incubation".

The AT visions of most of the DG participants can be interpreted as transition situations that can be located in Quadrants 1, 2 and 3. Certain adjustments in management practices are mentioned to improve the efficiency of external inputs, but only by reducing their pressure and to reduce environmental impacts at the property level (for example, precision agriculture or use of resistant varieties) associated with sustainable intensification. Suppose these views are analysed from the niche innovation standpoint. In that case, changes in management practices comprise a reductionist vision in associating niches with technological changes linked to the dominant socio-technical regime, whose axis is the increase of productivity. Although most public or private institutions do not yet have an explicit or consensual position on agroecology, they promote programs or projects to encourage "more sustainable production". In this line, we find natural pasture management projects, the introduction of service crops in agricultural rotation, among others, driven by research and transfer institutions and focused on the sustainability of productive systems.

"Regenerative" Agroecology: Quadrant 1 represents AT situations originating in crises or individual experiences of producers in direct relation to the conservation/regeneration of the resources available on their property. In this situation, niche innovations are looking for solutions with resources from the property itself, for example, land use intensification and subdividing into plots to manage pastures. Both DG provided examples of innovations that solve the effects of previous mismanagement on the property due to the need to avoid further degradation of natural resources, even to the detriment of production, but avoiding the use of external inputs. According to what is expressed in the professionals' DG, in these cases, the drivers for change are varied, from a talk with neighbours, projects or programs developed through organisations, to a field activity of an institution, at the territorial level.

"Industrial" Agroecology: the visions represented in Quadrant 2 are related to the niche innovations proposed by the market, which promote the inclusion of producers in agri-food value chains for export. Individual action is privileged, with technical proposals to improve the production system. Modifications are proposed within the current socio-technical regime but without transforming it. Innovations in the techniques and technologies that follow a protocol regulated by certifications for selling products in the export market are found in this quadrant. In the DG, examples were given on selling organic meat and certifications for sustainable and organic wool, which mainly correspond to wool from mixed establishments with an organic certification of beef production programs of cold-storage plants. The driver of change for these transformations are the industries themselves, according to market opportunities, who lead the way, and the drivers at the producer level are the value added to their production.

Agroecology "in incubation": in Quadrant 3, although there are clear commitments and ideas from some technicians, only a few think about the need for an AT and a displacement of the current socio-technical regime, mainly through the generation of niche innovations that are being installed little by little. In the DG of the producers, "producing without chemicals and living in accordance with nature" emerged as a felt need, and decisions were made for this purpose. Examples of innovations emerged with rotary grazing practices or rational grazing and the introduction of biological control (native bioinsecticide for ticks), among others. These innovations do not yet generate a redesign but drive changes in production logic.

Agroecology: Quadrant 4 shows the "objective" transition situation, in which there is the advance of a new socio-technical regime that would displace the current hegemonic one. Changes are promoted at different levels in family production systems and rural organisations, which generates niche innovations with the management of material resources in the territory through interaction and work with institutions and through public policies developed to accompany the AT. The type of action

required here is collective, and innovation is seen from a socio-technical perspective. This innovation is considered virtuous because it contributes to resilience and the fight against climate change in addition to installing agroecology, without forgetting that the participation of producers allows them to improve their innovation capacities by generating territorial learning necessary for the proper functioning of agroecology (CHIA, 2018; VITRY; CHIA, 2016). According to the participants of the DG, it is considered that even this strong agroecology is still in the early stages in Uruguay, and not everyone has a clear understanding of this perspective. In only one of the participating institutions of the DG of professionals, agroecology is part of the mission and vision, integrating the paradigm of production and development it seeks. In the rest, the position taken regarding agroecology has not been defined, nor is it part of its institutional mandate.

Alonso-Frajedas *et al*. (2020) mention that types of practices related to agriculture adapted to climate change, sustainable or ecological intensification, and industrial production of organic monoculture food, among others, are efforts of the co-optation of agroecology to refine the industrial food system. Looking at the matrix, in quadrants 1 and 2, the deconstruction devices align with the idea of the sustainability of the systems but without departing from the markets' rules or the dominant socio-technical regime, which aims to improve the systems' productivity rather than also focusing on the social inequality they cause.

Some researchers consider that these technologies are false solutions, referring to the fact that they are technological solutions but from a power perspective, where the industry is the one that marks the path which must be transited to generate sustainable merchandise, with the aim of marketing in certain specific market niches (PETERSEN; MONTEIRO, 2021). Producers are "tied" to these forms of production, and in a certain way, they manage their production not regarding nature but to the market. In short, the current hegemonic socio-technical regime of increased productivity and access to the global market is reproduced and fed, far from an agroecology that not only seeks to build a relationship of affection between nature and society (PETERSEN; MONTEIRO, 2021) but also promotes a political-institutional and structural change at the territorial level.

On the other hand, the situations of AT of Quadrants 3 and 4 tend to improve the relationship between nature and society based on respect for their own natural resources, with a strong process of recovery, which appeals to the rescue of ancestral knowledge. In Quadrant 3, however, the demand for the necessary structural change at the territorial level is unclear, where they can implement their own devices to promote food sovereignty and modify the predominant socio-technical regime. In this sense, it is important to highlight the role of public policies in terms of putting devices into operation that implement Law 19,717 on agroecological-based production in the territories.

5 CONCLUSION: PATHS AND PERSPECTIVES

The results confirm that the visions of the LFP depend on their property and family situation. Also, collective action at the territorial level structures production systems and agroecological practices, confirming that the paths or transitions to agroecology are multiple.

The comprehensive approach of the study highlighted the important role that actors and territories play in the deconstruction/reconstruction processes of the practices, strategies and visions from which the new agroecological production systems are implemented. The agricultural institutionality and rural organisations of the territory appear as key actors in the (re)construction of the new identity of the LFP through the generation of innovations and new ways of producing, which validates the role of the territories in the work of deconstructing actions to build new identities through new devices (public policies, institutional projects). However, from the perspective of agricultural professionals, deconstruction/(re)construction of what is thought about agroecology within institutions is a priority to then discuss the possibilities of generating key drivers of change.

The analysis matrix made it possible to interpret different paths of AT and ways in which innovations are introduced, involving from co-innovation methodologies and participatory action research to individual or group technical advice. Based on the different AT paths identified in family farming, it is possible to distinguish between situations of weak agroecology, some of which were adjectived as industrial agroecology and regenerative agroecology and others, such as those related to NF management or the use of bio-inputs, appear as innovation niches to begin a change in production logics.

Regarding the practices implemented, the results show that the northern LFPs do not take the same AT paths. This is important to consider when developing actions to accompany, support and guide the implementation of public policies. The paths towards strong agroecology in the north of the country seem to be multiple, and there is no dominant at the moment. In addition, thanks to different projects, FLPs are moving along different paths toward an agroecological way of production. The steps that guide these transformations result from the actors' interaction, either between producers (peer-to-peer dialogue) or by exchanging with professionals in the projects being developed. From these exchanges, socio-technical agreements and associated knowledge (enhancing local knowledge with the technical) arise, which affirm the need to conserve natural resources and promote the persistence of the family in the countryside. The situation generated by Law 19,717 and the call for organisations to participate in the Agroecological Path seem to be two opportunities to (re)build niche innovations that contribute to new socio-technical regimes, which allow for a transition towards a "strong" agroecology.

NOTES

1| The call for "Agroecological Path" projects was made in 2022. Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/noticias/senda-agroecologica-convocatoria-propuestas-transicion-agroecologica.

2| The MGAP, through the DGDR General Direction of Rural Development (DGDR) and with the support of the National Institute of Agricultural Research (INIA) within the Family Production Program, made 2 calls for projects to promote and develop appropriate technologies for family production, the first in 2014 and the second in 2016 https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/convocatoria/tecnologias-para-produccion-familiar.

3| SUL: Uruguayan Wool Secretariat, INIA: 4.1.1 National Agricultural Research Institute, IPA: Agricultural Plan Institute.

REFERENCES

ALBICETTE, M. M. *et al*. Co-innovación para promover sistemas ganaderos familiares más sostenibles en Uruguay. Análisis de tres años de cambios en la dimensión social de la sostenibilidad. **Revista Latinoamericana de Estudios Rurales**, v. 1, n. 2, p. 105-136, 2016. Available at: http://www.ceil-conicet.gov.ar/ojs/index.php/revistaalasru/article/view/181 Accessed on: may 2023.

ALONSO-FRADEJAS, A. *et al*. Agroecología Chatarra: la captura corporativa de la agroecología. **Transnational Institute**, 2020. Available at: https://www.tni.org/es/publicaci%C3%B3n/agroecologia-chatarra. Accessed on: may 2023.

ALTIERI, M. A. Agroecology: the science of natural resource management for poor farmers in marginal environments. **Agriculture, Ecosystems and Environment**, v. 93, p. 1-24, 2002. Available at: https://doi.org/10.1016/S0167-8809(02)00085-3

ALTIERI, M.; TOLEDO, V. M. The agroecological revolution of Latin America: rescuing nature, securing food sovereignity and empowering peasants. **The Journal of Peasant Studies**, v. 38, n. 3, p. 587–612, 2011. Available at: https://doi.org/10.1080/03066150.2011.582947

CHIA, E. La agroecología nuevo paradigma para la agricultura familiar y el desarrollo territorial. Contribución del tríptico virtuoso de la innovación, los aprendizajes y la gobernanza. **Revista Cangüé**, 40, p. 10-14, 2018. Available at: http://www.eemac.edu.uy/cangue/?view=projectyid=39:n-40-2018. Accessed on: may 2023.

CLAVEIROLE, C. **La Transition Agroécologique**: défis et enjeux. Le Conseil économique social et environnemental, 2016. Available at: https://www.lecese.fr/travaux-publies/la-transition-agroecologique-defis-et-enjeux. Accessed on: may 2023.

COMPAGNONE, C.; SIGWALT, A. L'espace social du souci des sols: récit et contre-récit d'agriculteurs vendéens en agriculture de conservation. **Natures Sciences Sociétés**, v. 29, n. 4, p. 410–422, 2021. Available at: https://doi.org/10.1051/nss/2022006

DÍAZ, P. El acceso a los campos públicos en la Cuchilla del Fuego, Paysandú, Uruguay. In: DÍAZ. P. (Ed.). **Observatorio de Política de Tierra**, v. 6, p. 73–89, 2021. Psicolibros Waslala.

DIÉGUEZ, F. Estudio de las finalidades de funcionamiento de un grupo de explotaciones familiares ganaderas extensivas. **Agrociencia Uruguay**, v. 18, n. 2, p. 158-148, 2014. Available at: https://doi.org/10.31285/AGRO.18.476

DOGLIOTTI, S. *et al*. Entregable 20 y 27. Protocolos y planes de medición para todas las variables. Proyecto GCP/URU/034/GFF. **Producción ganadera climáticamente inteligente y restauración del suelo en pastizales uruguayos**, 2020. Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/publicaciones/entregable-20-27-ganaderia-clima-protocolos-planes-medicion-para-todas Accessed on: may 2023.

DOTTA, M.; FREIRE, D.; RODRÍGUEZ, N. **El Uruguay Ganadero**. De La explotación primitiva a la crisis actual. Ediciones de la Banda Oriental, 1972, 169p.

DURU, M.; FARES, M.; THEROND, O. **Un cadre conceptuel pour penser maintenant (et organiser demain) la transition agroécologique de l'agriculture dans**. Available at: https://doi.org/10.1684/agr.2014.0691

ELZEN, B. *et al*. (Eds.) **Agroecological transitions**. Changes and breakthroughs inthe making. Wageningen University and Research, 2017. 302 p. Available at: https://doi.org/10.18174/407609

FRANCO, R. *et al*. Ganadería familiar y agroecología. Fortalecimiento de las sociedades pastoriles en Uruguay. **LEISA Revista de Agroecología**, v. 32, n. 4, p. 17–19, 2016. Available at: https://www.leisa-al.org/web/index.php/volumen-32-numero-4/2657-ganaderia-familiar-y-agroecologia-fortalecimiento-de-las-sociedades-pastoriles-en-uruguay. Accessed on: may 2023.

GAZZANO, I.; ACHKAR, M. Conflictos de las transformaciones territoriales: ganaderos frente a la intensificación agraria en Esteros de Farrapos Uruguay. **Revista Iberoamericana de Economía Ecológica**, v. 26, p. 109–121, 2016. Available at: https://hdl.handle.net/20.500.12008/22665. Accessed on: may 2023.

GAZZANO, I.; GÓMEZ PERAZZOLI, A. Agroecology in Uruguay. **Agroecology and Sustainable Food Systems**, v. 41, n 3-4, p. 380–400, 2017. Available at: https://doi.org/10.1080/21683565.2017.1286533

GAZZANO, I. *et al*. Ambiente y crisis en Uruguay. La agroecología como Construcción Contrahegemónica. **Revista de Ciencias Sociales**, v. 34, n. 48, 2020. Available at: https://doi.org/10.26489/rvs.v34i48.1

GEELS, F. W. Technological transitions as Evolutionary Reconfiguration Processes: a multi-level perspective and a case-study. **Research Policy**, v. 31, n. 8-9, p. 1257–1274, 2002. Available at: https://doi.org/10.1016/s0048-7333(02)00062-8

GLIESSMAN, S. R. **Agroecology**. Ecological processes for sustainable agriculture. Chicago, Sleeping Bear Press, 1998. 305p. Available at: https://doi.org/10.2134/jeq1999.00472425002800010046x

GUIBERT, M. *et al*. De Argentina a Uruguay: espacios y actores en una nueva lógica de producción agrícola. **Revista Pampa**, v. 7_sup, p. 13–38, 2011. Available at: https://doi.org/10.14409/pampa.v1i7_sup.3202

HAESBAERT, R. **Des-territorialização e identidade**: a rede gaúcha no Nordeste. Editora da Universidade Federal Fluminense, 1997, 293p. Available at: https://www.eduff.com.br/produto/des-territorializacao-e-identidade-a-rede-gaucha-no-nordeste-e-book-pdf-623. Accessed on: may 2023.

HILL, S. B. Redesigning the food system for sustainability. **Alternatives**, v. 12, p. 32–36, 1985. Available at: https://www.researchgate.net/publication/285538508_Redesigning_the_food_system_for_sustainability#fullTextFileContent. Accessed on: july 2023.

HLPE. **Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition**. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, 2019. Available at: https://www.fao.org/cfs/cfs-hlpe/publications/en. Accessed on: may 2023.

HORLINGS, L. G.; MARSDEN, T. K. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world.' **Global Environmental Change**, v. 21, n. 2, p. 441–452, 2011. Available at: https://doi.org/10.1016/j.gloenvcha.2011.01.004

KRUEGER, R. A.; CASEY, M. A. **Focus groups**: a practical guide for applied researchers (3rd ed.). Sage Publication, 2000, 215p.

MGAP; DIEA. **Censo General Agropecuario 2011** [Internet]. Montevideo: MGAP; 2014. Available at: https://bit.ly/3Fw8OpU. Accessed on: may 2023.

MGAP; DIEA. **Anuario Estadístico Agropecuario 2021** [Internet]. Montevideo: MGAP; 2021, 261p. Available at: https://bit.ly/3pyPJhp. Accessed on: may 2023.

MIER Y TERÁN, M. *et al*. Bringing agroecology to scale: key drivers and emblematic cases. **Agroecology and Sustainable Food Systems**, v. 42, n. 6, p. 637–665, 2018. Available at: https://doi.org/10.1080/21683565.2018.1443313

MODERNEL, P. *et al*. Identification of beef production farms in the Pampas and Campos area that stand out in economic and environmental performance. **Ecological Indicators**, v. 89, p. 770-755, 2018. Available at: https://doi.org/10.1016/j.ecolind.2018.01.038

ONWUEGBUZIE, A. J. *et al*. Un marco cualitativo para la recolección y análisis de datos en la investigación basada en grupos focales. **Paradigmas**, v. 3, p. 127-157, 2011. Available at: https://dialnet.unirioja.es/servlet/articulo?codigo=3798215. Accessed on: may 2023.

PAOLINO, C.; PITTALUGA, L.; MONDELLI, M. **Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas**. CEPAL – Serie Estudios y Perspectivas – Montevideo – N° 15, 2014, 98p. Available at: https://repositorio.cepal.org/bitstream/handle/11362/36780/S2014255_es.pdf?sequence=1&isAllowed=y. Accessed on: may 2023.

PETERSEN, P.; MONTEIRO, D. **Agroecología o colapso**. Publicaciones Articulação Nacional de Agroecologia. 2021. Available at: https://agroecologia.org.br/2021/01/09/agroecologia-o-colapso/. Accessed on: may 2023.

POSADA RODRIGUEZ, V.; POSADA, N.; RODRIGUEZ, A. Fabricar La Agroecología: lecciones de los proyectos de desarrollo social. **Agrociencia**, v. 24, (NE1), 2020. Available at: https://doi.org/10.31285/agro.24.363

RIBEIRO, C. M. Estudo do modo de vida dos pecuaristas familiares da região da Campanha do Rio Grande do Sul. (Tese de Doutorado) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2009, 303p. Available at: http://hdl.handle.net/10183/17261. Accessed on: may 2023.

ROSSI, V.; FILARDO, V.; CHIA, E. Tipos de Resistencia de la ganadería familiar en el Noroeste Uruguayo. **Eutopía, Revista de Desarrollo Económico Territorial**, v. 15, p. 33–56, 2019. Available at: https://doi.org/10.17141/eutopia.15.2019.3868

TITTONELL, P. Las transiciones agroecológicas: múltiples escalas, niveles y desafíos. **Revista FCA Uncuyo**, v. 51, n. 1, p. 231-246, 2019. Available at: https://revistas.uncu.edu.ar/ojs3/index.php/RFCA/article/view/2448. Accessed on: may 2023.

URUGUAY. Ley 19717/2018 de 21 de diciembre de 2018. Declaración de interés general y creación de una comisión honoraria nacional y plan nacional para el fomento de la producción con bases agroecológicas. C**entro de información oficial IMPO**, 2019. Available at: https://www.impo.com.uy/bases/leyes/19717-2018

VITRY, C.; CHIA, E. Contextualisation d'un instrument et apprentissages pour l'action collective. **Management y Avenir**, v. 83, n. 1, p. 121–141, 2016. Available at: https://doi.org/10.3917/mav.083.0121

Comprender los caminos agroecológicos de la ganadería en el norte de Uruguay

Understanding agroecological livestock pathways in northern Uruguay

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ARTICLE- VARIA

RESUMEN

La agroecología como modelo de producción alternativo al modelo dominante actual, es incipiente en Uruguay. Comprender e interpretar la visión que los productores y técnicos tienen sobre la transición agroecológica en el país es un desafío para la investigación. La principal hipótesis en este trabajo es que las visiones de los productores y técnicos sobre la agroecología, orientan, enmarcan y estructuran los procesos de transición. Se presentan resultados sobre las visiones de la agroecología de dos grupos de discusión realizados en 2020 con profesionales de diferentes instituciones y ganaderos familiares. Estos muestran la gran diversidad de visiones y los diferentes caminos que transitan los ganaderos. A pesar de estas visiones diferentes, se encuentran algunas ideas-fuerza comunes que podrían contribuir a la definición de un modelo de ganadería agroecológico. Los caminos permiten sugerir y evaluar propuestas diferenciadas para el desarrollo de una ganadería familiar agroecológica.

Palabras clave: Agricultura familiar. Agroecología. Grupos de discusión. Prácticas socio-técnicas.

ABSTRACT

Agroecology is emerging in Uruguay as an alternative production model. Understanding and interpreting the vision of farmers and rural technicians on the agroecological transition processes in the country is a

challenge for research. The main hypothesis that motivated this study is that the views of producers and technicians on agroecology guide, frame, and structure the transition processes. This article presents the results of two focus groups carried out in 2020 with professionals from different institutions and family livestock farmers in the north of the country. They show the great diversity of visions and the different paths taken by farmers. Despite these different visions, some common ideas could contribute to defining an agroecological livestock farming model. These paths permit suggesting and evaluating differentiated proposals for developing agroecological family farming.

Keywords: Family farming. Agroecology. Focus groups. Socio-technical practices.

1 INTRODUCCIÓN

La agroecología como modelo de producción alternativo al modelo productivista dominante en Uruguay, es incipiente. Siguiendo a Altieri y Toledo, se comprende como modelo de producción alternativo aquel que promueve la producción nacional y local de alimentos por familias productoras rurales (y sistemas de producción urbanos) a partir de la innovación, de recursos locales y el uso de energías alternativas, por ejemplo solar (ALTIERI; TOLEDO, 2011). A partir de la aprobación del Plan Nacional para el Fomento de la Producción con Bases Agroecológicas (PNA) se empieza a implementar la agroecología como política pública (GAZZANO *et al*., 2020). El PNA declara de interés nacional, "la promoción y el desarrollo de sistemas de producción, distribución y consumo de productos de base agroecológica, tanto en estado natural como elaborado, con el objetivo de fortalecer la soberanía y la seguridad alimentaria, contribuyendo al cuidado del ambiente, de manera de generar beneficios que mejoren la calidad de vida de los habitantes de la República" (LEY 19.717/2019 Art. 1).

Además, declara a los productores familiares agropecuarios y a los sistemas de producción agrícola urbana y suburbana, como los sujetos colectivos principales de los sistemas de producción de base agroecológica. Por otro lado, recientemente el Ministerio de Ganadería, Agricultura y Pesca (MGAP) convocó a las organizaciones de la producción agropecuaria, a presentar propuestas de transición agroecológica (TA) a través de la convocatoria "Senda Agroecológica"1. Esto constituye un escenario propicio para imaginar nuevos sistemas de producción basados en la biodiversidad y sustentables, que respeten los recursos naturales (GAZZANO *et al*., 2020; POSADA RODRÍGUEZ *et al*., 2020). En este contexto, comprender e interpretar las visiones de los productores y técnicos agropecuarios sobre los procesos de TA en el territorio, es un desafío para la investigación, las organizaciones y el Estado.

Se trata entonces de comenzar a transitar hacia una nueva situación, colocando en discusión el modelo productivo dominante. Transitar hacia un modelo de producción agroecológico permitiría dar respuesta al deterioro producido por el régimen socio-técnico dominante, lo que parece hoy como necesario y urgente (TITTONELL, 2019). Si bien en Uruguay las investigaciones sobre sistemas ganaderos familiares han analizado la cuestión de su sustentabilidad social, económica y ecológica (ALBICETTE *et al*., 2016; GAZZANO; GÓMEZ, 2017; MODERNEL *et al*., 2018), pocos trabajos se han interesado en estudiar estos sistemas desde una perspectiva agroecológica, analizando las dinámicas de TA de los productores ganaderos familiares (PGF) uruguayos a nivel de la producción ganadera. Algunos estudios señalan la necesidad de comprender mejor el manejo y conservación del Campo Natural (CN) que realizan los PGF y así generar cambios a través del trabajo colaborativo entre técnicos y productores familiares (ALBICETTE *et al*., 2016; DIÉGUEZ, 2014).

Por otro lado, las exportaciones de carne bovina que realiza el país le han permitido acceder, de la mano de innovaciones y estrategias de diferenciación, a nichos especializados del mercado de carne de alta calidad (PAOLINO *et al*., 2014). Debido a que la ganadería realiza una contribución de aproximadamente 40% del PIB agropecuario (MGAP, 2021), los desafíos de la TA son aún mayores. El sistema de producción ganadero extensivo sobre CN (predominante), se inició hace más de cuatrocientos años con la introducción del ganado a la región pampeana del Río de la Plata, dando lugar a lo que se

denominó Uruguay Pastoril (DOTTA *et al*., 1972). Este sistema de producción determinó también la fuerte presencia en el país de un tipo de PGF (ganaderos tradicionales), dedicados sobre todo a la cría ganadera (RIBEIRO, 2009). Estos PGF, pueden ser considerados un tipo especial de agricultor familiar, sobre todo los "criadores", dedicados a la cría mixta bovina y ovina, que no incluyen agricultura ni procesos de terminación vacuno (ROSSI *et al*., 2019). El avance de los procesos de intensificación agrícola llevó a que hoy la ganadería de cría compita por la utilización de los recursos naturales con la agricultura y la silvicultura en el país (GAZZANO; ACHKAR, 2016). Entre los años 2000 y 2011 la superficie de las regiones agropecuarias agrícola y silvícola aumentaron un 110 y 158% respectivamente, mientras que la ganadería descendió un 36% (MGAP DIEA, 2021). Aún a pesar del avance evidente del modelo de agricultura y silvicultura intensiva promovido por el agronegocio (GUIBERT *et al*., 2011), según el último Censo General Agropecuario la mayor parte de la superficie explotada en el país (39%), corresponde a la ganadería sobre CN (MGAP DIEA, 2014).

En cuanto a la estratificación social, existen 21.657 explotaciones familiares en el país (MGAP DIEA, 2021), lo que representa casi la mitad del total de explotaciones respecto al año 2011. El 65,4% de los productores familiares declaran como producción principal el ganado bovino (carne o leche) u ovino (carne y lana); la mayoría de ellos en base a CN (MGAP DIEA, 2021). El modo de vida de las familias, su relación con la naturaleza y el paisaje son característicos de una cultura y tradición "*gaucha*" que prevalecen en la toma de decisiones en la región pampeana (RIBEIRO, 2009). Son familias que generalmente tienen bajos ingresos relativos, principalmente por su pequeña escala y por el estilo de vida y de trabajo, que determinan el uso de fuerza de trabajo familiar y una baja incorporación de tecnologías basadas en insumos (DOGLIOTTI *et al*., 2020). Estas familias ganaderas persisten y se agrupan en organizaciones de base en el territorio, desarrollando resistencias individuales y colectivas al avance del agronegocio, como las demandas sectoriales de políticas de acceso a la tierra y de apoyo para capacitación y asesoramiento técnico (DÍAZ, 2021; ROSSI *et al*., 2019).

En este sentido, desde la institucionalidad agropecuaria se han generado convocatorias y proyectos en los que se han contratado técnicos para trabajar con las organizaciones de productores familiares. Entre estas convocatorias fueron importantes las de fortalecimiento institucional, la promoción de tecnologías para la producción familiar y las dirigidas a mujeres y jóvenes (FRANCO *et al*., 2016). Si bien en muchos casos, estas convocatorias han reforzado la asistencia técnica a los PGF y sus organizaciones en la zona de estudio, el fortalecimiento de la producción familiar implica no sólo asesorar, sino también comprender y respetar las singularidades que subyacen en los sistemas productivos, y más aún desde la perspectiva de la TA.

El objetivo del estudio fue comprender e interpretar la visión que los productores y técnicos tienen sobre la TA en el territorio ganadero del norte del país, discutiendo particularmente qué entienden los diferentes actores sobre la misma y sobre la agroecología. En este marco, se plantea como supuesto que la (re)construcción del sistema de producción ganadero familiar agroecológico va a depender de su situación, objetivos y de la visión que los productores tienen de la agroecología, por ende, esto va a orientar el proceso de transición. De esta manera se pretende contribuir en la comprensión del rol de la institucionalidad pública y privada y de las organizaciones de los PGF en la transición hacia un modelo de producción agroecológico.

El documento se divide en cuatro secciones. En la primera se presenta el marco teórico conceptual y en la segunda la metodología utilizada. En la tercera sección se presentan los resultados, se desarrollan las visiones de los participantes en los grupos de discusión, sobre agroecología y TA, y la matriz de análisis que nos permitió interpretar las diferentes propuestas o caminos de TA. Finalmente, a partir de las diferentes visiones y propuestas de TA identificadas, se reflexiona sobre la manera en que los PGF del norte transitan hacia un modelo de producción agroecológico

2 TRANSICIÓN AGROECOLÓGICA: MÚLTIPLES CAMINOS

La transición no es una temática reciente, ya en los años 80, Stuart Hill proponía la necesidad de rediseñar sistemas productivos señalando la importancia de realizar un cambio profundo para la transformación de una agricultura convencional a una ecológica. Si bien no se definía específicamente una TA, se ponía principal relevancia en la relación humano-naturaleza además de la importancia en la eficiencia del uso de insumos químicos y cambio al uso de insumos orgánicos (HILL, 1985).

En este sentido Gliessman (1998), menciona una serie de niveles necesarios para transitar hacia la agroecología, que acompañan no sólo el rediseño en la explotación agropecuaria sino la relación entre diferentes actores (productores y consumidores). Es así, que nos vamos acercando a un pensamiento de construcción que parte de lo individual pero incluye cambios multilineares y escalares (ELZEN *et al*., 2017).

En este trabajo la TA se comprende como un proceso de deconstrucción/construcción a nivel individual, en las explotaciones agrícolas, y colectivo en el territorio, que responde al desafío de implementar procesos de concepción, selección y difusión de innovaciones para una transformación agroecológica (VITRY; CHIA, 2016). Desde esta perspectiva, los territorios pasan a ser dispositivos donde los productores y técnicos van a experimentar nuevas prácticas, nuevas alianzas y relaciones (CHIA, 2018). El territorio es clave en la definición de qué conviene hacer para alcanzar sistemas de producción agroecológicos, ya que involucra aspectos culturales, de identidad y de control simbólico sobre el espacio (HAESBAERT, 1997).

El proceso de TA, se entiende como cambios e innovaciones socio-técnicas y organizacionales, producto de la interacción de múltiples actores y en diferentes escalas (local, nacional, regional), que pone en juego fenómenos con múltiples dimensiones (físicas, políticas, técnicas, sociales, financieras, y científicas) lo que habilita a considerar los procesos de TA como situaciones complejas e inciertas (CHIA, 2018). Durante este proceso de TA los actores juegan un papel importante en la transformación del territorio, a través de fuerzas impulsoras (MIER Y TERÁN *et al*., 2018; TITTONELL, 2019), que permiten generar innovaciones y que producen cambios. Pero éstos no son lineales, sino que se dan como un proceso de deconstrucción/(re)construcción producido por los actores locales en procesos dinámicos de ida y vuelta, de traducciones y alianzas múltiples donde productores, extensionistas e investigadores se unen para co-concebir las innovaciones, implementarlas y evaluarlas. Es lo que Geels (2002), en su proposición teórica para analizar las transiciones socio-técnicas, denomina como innovaciones de nicho (cambios, prácticas a nivel de las unidades y las localidades).

Según Geels (2002), las transiciones resultarían (i) por los cambios a nivel de los paisajes socio-técnico a través de las leyes o programas nacionales que van a modificar las relaciones a nivel de los regímenes socio-técnico y favorece algunas innovaciones de nicho; (ii) por los cambios en los regímenes socio-técnicos que determinarán cambios en el paisaje y en los nichos de innovación. Para generar cambios en los regímenes socio-técnicos es necesario que las acciones decididas en el paisaje socio-técnico y las acciones realizadas en los nichos, ocurran para modificar las relaciones entre los diferentes componentes del régimen socio-técnico y (iii) por la aparición de innovaciones de nicho, producto de nuevas prácticas individuales o de grupos reducidos que poco a poco van a modificar el régimen socio-técnico modificando las relaciones y los proyectos de las instituciones. Es así que las innovaciones de nicho contribuyen a generan nuevos caminos para transitar hacia otra forma de producir o modo de producción.

En agroecología, la transición es vista como un conjunto de procesos, de caminos simultáneos a diferentes escalas, niveles y dimensiones, donde se combinan las transformaciones a nivel de estructuras tróficas de comunidades del suelo, a nivel de la familia rural con sus roles y responsabilidades (CLAVEIROLE, 2016; TITTONELL, 2019) con aquellas transformaciones a nivel socio-técnico, político y cultural en los territorios (CLAVEIROLE, 2016; MIER Y TERAN *et al*., 2018). La agroecología no tiene aún una definición unánime (ALTIERI, 2002), lo que dificulta la tarea de estudiarla, pero al mismo tiempo, ese no-consenso la hace potencialmente más interesante, porque permite explorarla de diferentes ángulos.

Entre los debates teóricos sobre la modernización ecológica se mencionan dos formas de agroecología (DURU *et al*., 2014; HORLINGS; MARSDEN, 2011). La "débil" que hace mención a un tipo de modernización en donde se aplican las buenas prácticas de manejo para mejorar la eficiencia del uso de insumos externos y reducir impactos ambientales. La forma "fuerte" de la agroecología corresponde con un cambio de paradigma, donde se busca sustituir los insumos clásicos (de síntesis química) por la utilización de la diversidad biológica de los agroecosistemas y además se busca un nuevo "diseño" de los sistemas de producción, basado en la complementariedad entre las producciones.

Como ejemplo de la primera, la propuesta de intensificación sostenible implica un proceso de mejora gradual de la eficiencia ecológica de los sistemas agropecuarios a través de la innovación, con el fin de propender a una mayor o igual productividad y rentabilidad con menor impacto ambiental, al mantenimiento y/o mejora de los recursos naturales, reduciendo la dependencia de insumos externos (HLPE, 2019). Según Alonso-Fradejas *et al*. (2020), estas medidas disminuyen los problemas ambientales, pero aún siguen ocurriendo efectos negativos ya que es un enfoque que se orienta a mantener el orden establecido del capital agroalimentario y al mismo tiempo incorpora discursos, prácticas y procesos propios de un enfoque agroecológico. Para la segunda forma, se requiere de un enfoque sistémico que apunte a través de la movilización de la biodiversidad la (re)concepción y la co-concepción de los sistemas agropecuarios (DURU *et al*., 2014). Esta forma es más compleja ya que es necesario revisar los modelos de gestión de las explotaciones, de las organizaciones sociales y rurales y los recursos en un territorio, todo acompañado de políticas públicas que sostengan esta transición (DURU *et al*., 2014; HORLINGS; MARSDEN, 2011).

Se trata de cambios individuales y colectivos que implican múltiples innovaciones a diferentes niveles. Las innovaciones de nichos (GEELS, 2002; TITTONELL, 2019) requieren de nuevas capacidades de coordinación entre los actores y aprendizajes específicos tales como el pensamiento sistémico, las dinámicas organizacionales, la hibridación de conocimientos (VITRY; CHIA, 2016). Debido a la complejidad de los cambios en todos los niveles, varios pueden ser los caminos en la transición de acuerdo a las características de los modelos productivos y de las innovaciones y por lo tanto, estos caminos podrán acercar más o menos a los sistemas productivos a ser agroecológicos. Esta investigación pretende también, contribuir a documentar esta controversia entre la agroecología débil y fuerte para comprender mejor la complejidad de la agroecología.

3 METODOLOGÍA: UN ENFOQUE COMPRENSIVO DE LA AGROECOLOGÍA

La investigación se llevó a cabo en los departamentos de Salto y Tacuarembó (norte de Uruguay), caracterizados por ganadería extensiva sobre CN (MGAP DIEA, 2021). La metodología utilizada fueron los grupos de discusión (GD), que responde al enfoque de investigación cualitativa de tipo comprensivo y se seleccionó para facilitar una aproximación al punto de vista de los actores. Utilizar esta técnica se justificó porque lo que se dice individualmente es diferente a lo que se dice en un grupo (COMPAGNONE; SIGWALT, 2021), ya que en el grupo se genera un sentimiento de pertenencia que contribuye a la seguridad para compartir la información (ONWUEGBUZIE *et al*., 2011). Además, la técnica permite generar muchos datos de forma rápida y eficiente (KRUEGER; CASEY, 2000).

Los criterios de selección de los participantes se basaron en información que surgió de dos entrevistas exploratorias realizadas a informantes calificados de la región. Quienes realizaron una puesta a punto de la institucionalidad presente y del desarrollo de innovaciones de interés para estudiar la TA en ganadería, tales como el control de la carga de pastoreo según disponibilidad de materia seca en CN y el uso de control biológico de garrapatas con entomopatógenos nativos.

Se realizaron dos GD, uno integrado por 10 profesionales agropecuarios que pertenecían a la institucionalidad pública y/o privada presente en la región y estaban vinculados con organizaciones rurales a través de programas-proyectos, o vinculados como asesores técnicos privados. El otro GD fue

integrado por siete PGF vinculados a organizaciones sociales-rurales de la región y estaban involucrados en programas con alguna de las tecnologías de proceso que fueron definidas de interés para la investigación. Los GD fueron conformados según Onwuegbuzie *et al*. (2011) entre 6 y 12 participantes para generar una masa de información diversa dentro del grupo, sin inhibir el intercambio de diferentes opiniones, experiencias o creencias.

Cada GD insumió media jornada de trabajo, y tuvieron como objetivos específicos explorar la visión de los técnicos/productores y de sus instituciones/organizaciones frente a la agroecología y la TA, comprender el papel que están jugando las instituciones/organizaciones en la implementación de las innovaciones (cambios en las prácticas de manejo y tecnologías de proceso) y cuáles imaginan que serán las estrategias de acción para una transición agroecológica. En ambos grupos se combinaron trabajos individuales y talleres grupales con puesta en común y discusión plenaria.

4 RESULTADOS Y DISCUSIÓN: MÚLTIPLES VISIONES Y CAMINOS

4.1 GRUPO DISCUSIÓN DE TÉCNICOS

Existió acuerdo en la necesidad de reconstruir a nivel de territorio, lo que se piensa sobre la agroecología en interacción con la institucionalidad agropecuaria y con los profesionales que trabajan en ésta, aprovechando las acciones colectivas para identificar impulsores claves de los cambios o innovaciones.

Se identificaron algunas limitantes al interior de las instituciones para promover la TA, donde se destaca "los propios mandatos de las instituciones, ya que no hay una definición clara de agroecología". Los participantes consideran que es más por omisión que por oposición a la agroecología, aunque hubo acuerdo de que existe la idea de que la agroecología "es para los hippies […] utópico, difícil de lograr" y de que algunos referentes de las instituciones "le restan importancia a la agroecología, e incluso se 'burlan' de ciertas prácticas de manejo como el pastoreo Voisin, y eso tiene un impacto tremendo en los productores". Aunque de todas maneras, "hay una visión de promoción, difusión de las alternativas ecológicas para la vida y la producción, partiendo de la base que la sociedad necesita conocer lo que existe para cambiar, co-innovar, crear, las alternativas y el cambio".

Se destacó el rol de algunos proyectos que contribuyeron a poner en discusión las maneras de producir, como los del Programa "Más Tecnología para la Producción Familiar"2, que promovieron bajo la modalidad de investigación-acción-participativa, alternativas de manejo más cuidadosas con el ambiente, en donde fue clave el trabajo en conjunto entre instituciones y organizaciones. Se problematizó el rol cognitivo y la necesidad de innovar en la forma de pensar la producción ganadera. Para generar "un cambio de la conciencia" es necesario voluntad, para los técnicos se antepone "el querer cambiar y tomar la decisión" para iniciar el camino de la TA. Al contrario de lo que pudiera esperarse, el GD de los profesionales no enfatizó en la necesidad de transformaciones/innovaciones para la TA desde una dimensión técnico-productiva. Priorizó la dimensión cognitiva (la voluntad de cambiar) y el rol de los proyectos, como impulsores de innovaciones desde lo institucional, aunque no necesariamente ligados a una visión transformadora del modo de producción.

4.2 GRUPO DISCUSIÓN DE PGF

Existió acuerdo sobre la necesidad de que sus organizaciones discutan el concepto de agroecología y lo que entienden por TA, destacando como el principal instrumento el diálogo entre pares y mantener el apoyo de la institucionalidad presente en el territorio (a través del acompañamiento técnico, social y productivo) en los procesos de cambio. En este sentido, los ganaderos destacaron que los proyectos que "aterrizaron" en la zona brindaron apoyo para el asesoramiento técnico, social y productivo, y

habilitaron el acceso a diferentes tipos de capacitaciones, desde cómo formar un grupo hasta cursos de sanidad del ganado ovino y vacuno. Así, se rescató que "desde la organización de la zona hemos tenido muchísimas posibilidades de crecimiento, de que los técnicos nos capaciten, de que venga el SUL, el INIA, el IPA3, todos con distintos proyectos o con charlas informativas […]". Es necesario "entre todos […] hacer oír nuestras voces porque nosotros necesitamos cosas y aprendizajes y técnicos que nos apoyen. Nosotros estamos dispuestos a los cambios, ¡sí estamos!".

Las percepciones de este GD sobre la agroecología se sustentan, sobre todo, en la manera de relacionarse con la naturaleza, con el medio ambiente y en cómo ellos producen. Las reflexiones abarcan las dimensiones ambientales y productivas dejando de lado, las dimensiones sociales y culturales en el trabajo grupal. Los productores declararon que agroecología "me significa cuidar el medio ambiente en general y no ser dependiente de los químicos", "preservar el "campo" de la manera ecológica, evitando el uso de agroquímicos, porque se puede llegar a un resultado similar de forma ecológica", o "La forma más natural menos nociva para el desarrollo de la producción, para obtener una alimentación más saludable y bienestar del entorno".

Para este GD, la agroecología aún no se asocia a una forma integral de producir, comercializar, relacionarse y vivir. Sin embargo hay muchas cuestiones desde el trabajo en sus organizaciones que finalmente los llevan a reflexionar e imaginar desde otras dimensiones que forman parte de un pensamiento integral asociado a la agroecología, sobre todo cuando se trata de cambios e innovaciones que los hacen avanzar hacia otros modelos de producción y de vida. Además, en esta situación de redefinición para los PGF, aparece el rol de las organizaciones como promotora de estos cambios ya que la organización estructura de manera diferente la posición de éstos frente a la innovación, no sólo porque aumenta el acceso a la información y a diferentes proyectos, sino porque la comunicación entre pares se enriquece.

4.3 PUNTOS DE VISTA COMUNES

TSe resaltó el rol de la institucionalidad y de las organizaciones a la hora de proponer cambios en la región, construyendo identidad y generando acciones colectivas. Esta construcción de identidad colectiva define el marco socio-técnico para acciones que deconstruyan maneras de producir y vivir y reconstruyan otras.

Se destacó la importancia de experimentar situaciones que obligan a "hacer el click", que operan como impulsores clave en el camino hacia la TA (MIER Y TERAN *et al*., 2018; TITTONELL, 2019). Estos impulsores clave en un territorio pueden actuar interrelacionados o no, incluso estar unidos a una crisis determinada lo que impulsa a buscar alternativas a través de las organizaciones sociales y/o rurales, oportunidades a través de políticas públicas u otros dispositivos territoriales, como pueden ser medidas cautelares para la protección de una cuenca.

Entre los profesionales se mencionó el "indiscutible rol de las organizaciones en la construcción" de sistemas agroecológicos; la "importancia de una construcción colectiva y no individual", mientras que entre los productores se remarcó la importancia de llegar, "desde las organizaciones e instituciones a esas personas en el medio rural" que sobre todo se abren "al diálogo entre pares", porque "el productor antes era individualista, ahora apunta al colectivo; el productor antes era "yo"… quedan algunos, pero ahora somos "nosotros".

De manera general, los cambios discutidos en los GD que sería necesario imaginar para una transición ganadera a la agroecología se refirieron a innovaciones en las prácticas de manejo, promovidos por las organizaciones a través de charlas, capacitaciones y proyectos que lleguen a las organizaciones rurales y en donde participen los técnicos como parte de la institucionalidad en el territorio. En este sentido, es interesante esta imagen, porque la TA siempre comienza por cambios en las prácticas de manejo de un sistema productivo, aunque idealmente se considere que debería comenzar por un rediseño

del agroecosistema, con el consecuente cambio en las prácticas de manejo (TITTONELL, 2019). Son maneras de producir que se posicionan en fases intermedias entre la agroecología débil y fuerte. Esto se debe tener en cuenta además, porque la TA vista como un proceso de cambio hacia un modo de producción diferente, depende de las especificidades del territorio, no solo biofísicas sino también económicas, sociales e institucionales.

4.4 MATRIZ DE ANÁLISIS PARA LA TRANSICIÓN AGROECOLÓGICA

Con el objetivo de comprender y analizar la diversidad de opiniones y puntos de vista de los técnicos y PGF, se utilizó una matriz analítica que facilitó la comprensión e interpretración de los resultados de los GD, en términos de responder la siguiente pregunta: ¿hacia dónde se transita?.

La matriz se diseñó teniendo en cuenta el marco teórico de Geels (2002) para analizar transiciones socio-técnicas, en este caso, transiciones hacia la agroecología. Geels propone identificar tres niveles de acción, (i) el paisaje sociotécnico, en este caso marcado por el PNA y la convocatoria Senda Agroecológica en la producción ganadera en el norte de Uruguay; (ii) los regímenes socio-técnicos, configurados en la relación entre las institucionalidad pública y privada y los PGF en los diferentes paradigmas de producción; (iii) las innovaciones de nicho, definidas por los cambios en las prácticas como en este caso el uso de biogarrapaticida, o el ajuste de carga mediante medición de altura de pasto.

Considerando a la ganadería familiar del norte de Uruguay, el eje horizontal de la Figura 1 representa la trayectoria de la TA entre dos paradigmas o modelos de producción, desde la agricultura productivista hasta la agricultura agroecológica. A su vez, en el eje vertical representa los niveles de acción de las innovaciones involucradas en la TA, definiendo los extremos desde el nivel individual al colectivo. El cruce de estos dos ejes produce cuatro cuadrantes: tres representan situaciones en las cuales se desarrollan las innovaciones en la ganadería del norte uruguayo (cuadrantes 1, 2 y 3) y uno la situación de agroecología, como situación ideal a alcanzar por la TA (Cuadrante 4).

Dentro de cada cuadrante se describen las características asociadas a los caminos de TA según cuatro variables, (i) objetivos técnicos: se visualizan los aspectos de la producción; (ii) comercialización: se observan los canales de comercialización asociados a cada forma de producir; (iii) territorio: es la relación de los actores con el territorio; (iv) coordinación: es la relación de los actores con los otros niveles (instituciones, organizaciones, mercados).

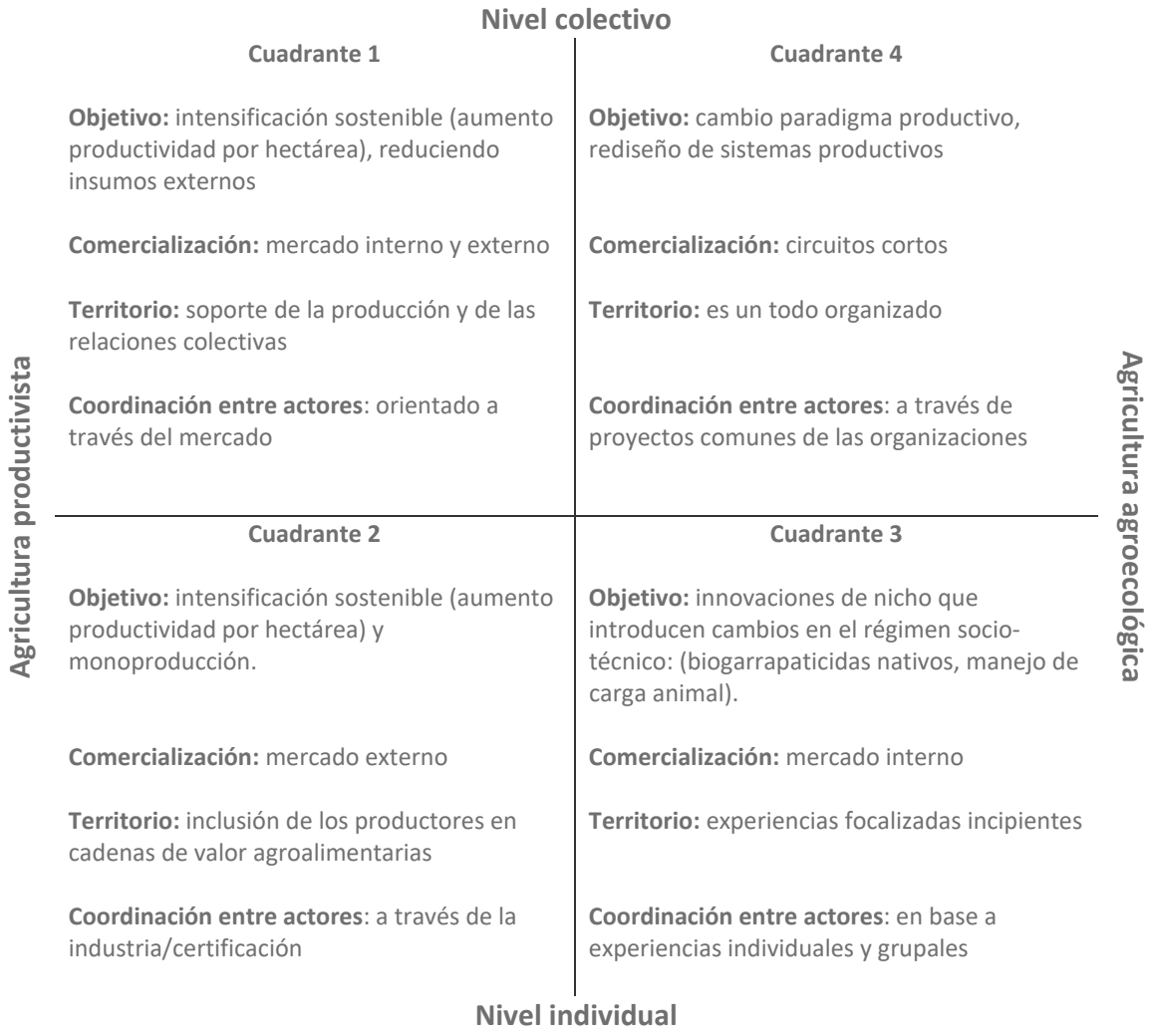

Figura 1 | Matriz de análisis de las diferentes transiciones agroecológicas para la ganadería uruguaya

Source: Prepared by the author.

Desde esta lógica, los Cuadrantes 1 y 2 corresponden a dos situaciones de TA que podemos considerar más cercanas al paradigma actual de agricultura productivista. En el Cuadrante 1 predominan las innovaciones de tipo colectivas, que referimos como "agroecología regenerativa". En el Cuadrante 2 predominan innovaciones de tipo predial o de "porteras adentro" y las denominamos como "agroecología industrial". Los Cuadrantes 3 y 4 son situaciones más cercanas al paradigma agroecológico, y la ubicación entre el cuadrante superior y el inferior, depende del tipo de innovaciones y de las relaciones con el territorio. Del estudio realizado se visualizan algunas innovaciones de nicho que pueden ser ubicadas en el Cuadrante 3, siendo "semillas" que pueden "germinar" en los territorios para alcanzar en el futuro situaciones de agroecología fuerte, a este cuadrante se le denominó "agroecología en incubación".

Las visiones sobre la TA de la mayor parte de los participantes en los GD se pueden interpretar como situaciones de transición que pueden ser ubicadas en los Cuadrantes 1, 2 y 3. Se mencionan ciertos ajustes en prácticas de manejo para mejorar la eficiencia del uso de insumos externos, pero solo disminuyendo su presión y con el fin de reducir impactos ambientales a nivel predial (por ejemplo, agricultura de precisión o uso de variedades resistentes), asociadas a la intensificación sostenible. Si se analizan estas visiones desde la perspectiva de las innovaciones de nicho, los cambios en las prácticas de manejo comprenden una visión reduccionista, en el sentido de asociar los nichos a cambios tecnológicos

que se asocian al régimen sociotécnico dominante, cuyo eje es el aumento de la productividad. Si bien la mayoría de las instituciones públicas o privadas no tienen aún una posición explícita ni consensuada frente a la agroecología, promueven programas o proyectos para incentivar "una producción más sostenible". En esta línea encontramos los proyectos de gestión de pasturas naturales, la introducción de cultivos de servicio en la rotación agrícola, entre otros, impulsados por instituciones de investigación y transferencia y centrados en la sostenibilidad de los sistemas productivos.

Agroecología "regenerativa": el Cuadrante1 representa situaciones de TA originadas en crisis o vivencias individuales de los productores, en relación directa con la conservación/regeneración de los recursos disponibles en su predio. En esta situación las innovaciones de nicho se dan buscando soluciones con recursos del propio predio, por ejemplo intensificación de uso de suelo, subdividiendo en parcelas para gestionar el pasto. Se dieron ejemplos en ambos GD de innovaciones que resultan para resolver efectos de un mal manejo anterior en el predio, por la necesidad evitar mayor degradación de los recursos naturales, aún en detrimento de la producción, pero evitando el uso de insumos externos. De acuerdo a lo expresado en el GD de los profesionales, en esos casos los impulsores al cambio son variados, desde una charla con vecinos, proyectos o programas desarrollados a través de organizaciones, hasta una actividad de campo de alguna Institución, a nivel del territorio.

Agroecología "industrial": las visiones que quedan representadas en el Cuadrante 2 tienen relación con las innovaciones de nicho propuestas por el mercado, que impulsan la inclusión de los productores en cadenas de valor agroalimentarias para exportación. Se privilegia la acción individual, con propuestas técnicas para mejorar el sistema de producción. Se proponen modificaciones dentro del régimen socio-técnico actual pero sin transformarlo. Se encuentran en este cuadrante aquellas innovaciones en las técnicas y tecnologías utilizadas que siguen un protocolo pautado por certificaciones para la venta de productos en el mercado de exportación. En los GD se pusieron ejemplos sobre la venta de carne ecológica, las certificaciones para lana sustentable y orgánica, que corresponden principalmente a lana proveniente de establecimientos mixtos con una certificación orgánica de programas de producción de carne vacuna de frigoríficos. El impulsor de cambio para estas transformaciones son las propias industrias de acuerdo a las oportunidades de mercado, quienes marcan el camino, y los impulsores a nivel de los productores son el valor agregado a su producción.

Agroecología "en incubación": en el Cuadrante 3 si bien hay compromisos e ideas claras de algunos técnicos, sólo unos pocos piensan en la necesidad de una TA y un desplazamiento del régimen socio-técnico actual, fundamentalmente a través de la generación de innovaciones de nicho que se vayan instalando de a poco. En el GD de los productores surgió como necesidad sentida "producir sin productos químicos y vivir acorde con la naturaleza" e ir tomando las decisiones con esta finalidad. Surgieron ejemplos de innovaciones con las prácticas de pastoreo rotativo o el pastoreo racional y la introducción de control biológico (biogarrapaticida nativo), entre otros. Son innovaciones que aún no generan un rediseño pero que impulsan cambios en las lógicas de producción.

Agroecología: el Cuadrante 4 muestra la situación de transición "objetivo", en la cual se produce el avance de un nuevo régimen socio-técnico que desplazaría al hegemónico actual. Se impulsan cambios a diferentes niveles, en los sistemas familiares de producción, en las organizaciones rurales, lo que genera innovaciones de nicho con manejos de recursos materiales en el territorio a través de la interacción y el trabajo con la institucionalidad y a través de políticas públicas desarrolladas para acompañar la TA. El tipo de acción requerida aquí es colectiva y la innovación es vista desde una perspectiva socio-técnica. Esta innovación es considerada virtuosa, porque además de instalar la agroecología, contribuye a la resiliencia y a la lucha contra el cambio climático. Sin olvidar que la participación de los productores les permite mejorar sus capacidades de innovación generando aprendizajes territoriales necesarios para el buen funcionamiento de la agroecología (CHIA, 2018; VITRY; CHIA, 2016). De acuerdo a los participantes de los GD, se considera que aún esta agroecología fuerte es incipiente en Uruguay e incluso que no todas las personas tienen clara esta perspectiva. En sólo una de las instituciones participantes del GD de los profesionales, la agroecología es parte de la misión y visión, integrando el paradigma de producción y desarrollo que la misma busca. En todas las demás, la posición a tomar en relación a la agroecología no ha sido definida ni forma parte de su mandato institucional.

Alonso-Frajedas *et al*. (2020) mencionan que los tipos de prácticas relacionadas a la agricultura adaptada al cambio climático, la intensificación sostenible o ecológica, la producción industrial en monocultivo de alimentos orgánicos, entre otras, son esfuerzos de la cooptación de la agroecología para afinar el sistema alimentario industrial. Observando la matriz, en los cuadrantes 1 y 2 los dispositivos de deconstrucción se alinean con la idea de la sustentabilidad de los sistemas, pero sin alejarse de la regla de los mercados ni el régimen socio-técnico dominante, que persigue el objetivo de mejorar la productividad de los sistemas más que centrarse además en la desigualdad social que estos provocan.

Algunos investigadores consideran que estas tecnologías son falsas soluciones haciendo referencia a que son soluciones tecnológicas pero desde una perspectiva de poder, es la industria la que marca el camino por el cual se debe transitar para generar mercancía sostenible, con el objetivo de comercializar en ciertos nichos específicos de mercado (PETERSEN; MONTEIRO, 2021). Los productores quedan "atados" a estas formas de producción y en cierta manera, manejan su producción no en relación con la naturaleza, sino con el mercado. En definitiva se reproduce y se alimenta el mismo régimen socio-técnico hegemónico actual de aumento de productividad y acceso al mercado global, lejos de una agroecología que no solo busca construir una relación de afecto entre la naturaleza y la sociedad (PETERSEN; MONTEIRO, 2021), sino que promueve un cambio político-institucional y estructural a nivel del territorio.

Por otro lado, las situaciones de TA de los Cuadrantes 3 y 4 tienden a mejorar la relación entre la naturaleza y sociedad basadas en el respeto de los propios recursos naturales, con un fuerte proceso de recuperación, que apela al rescate de los saberes ancestrales. Pero en el Cuadrante 3 no está clara la reivindicación del necesario cambio estructural a nivel de territorio donde se puedan generar dispositivos propios para promover una soberanía alimentaria y modificar el régimen socio-técnico predominante. En este sentido, es importante destacar el papel de las políticas públicas en lo relacionado a poner a funcionar dispositivos en los territorios que implementen la Ley 19.717 de producción con bases agroecológicas.

5 CONCLUSIÓN: CAMINOS Y PERSPECTIVAS

Los resultados confirman que las visiones de los PGF dependen de su situación predial y familiar. Pero también, la acción colectiva a nivel del territorio estructura los sistemas de producción y las prácticas agroecológicas, confirmando la idea de que los caminos o transiciones hacia la agroecología son múltiples.

El enfoque comprensivo del estudio, dejo en evidencia el importante rol que juegan los actores y los territorios en los procesos de deconstrucción/reconstrucción de las prácticas, estrategias y visiones a partir de las cuales se implementan los nuevos sistemas de producción agroecológicos. La institucionalidad agropecuaria y las organizaciones rurales del territorio aparecen como actores clave en la (re)construcción de la nueva identidad de los PGF, a través de la generación de innovaciones y nuevas formas de producir, lo que valida el rol de los territorios en el trabajo de deconstruir acciones para construir nuevas identidades a través de nuevos dispositivos (políticas públicas, proyectos institucionales). Sin embargo, desde la visión de los profesionales agropecuarios es prioritario el trabajo de deconstrucción/(re)construcción de lo que se piensa sobre la agroecología a la interna de las instituciones, para discutir luego las posibilidades de generar impulsores claves de cambio.

La matriz de análisis permitió interpretar diferentes caminos de TA y formas en las que se introducen las innovaciones, involucrando desde metodologías de co-innovación e investigación acción participativa, hasta el asesoramiento técnico individual o grupal. Apoyándose en los diferentes caminos de TA identificadas en ganadería familiar, es posible distinguir entre situaciones de agroecología débil, algunas de las cuales se adjetivaron como agroecología industrial y agroecología regenerativa y otras, como las relativas a la gestión de CN o la utilización de bioinsumos, aparecen como nichos de innovación para comenzar un cambio en las lógicas de producción.

Con respecto a las prácticas implementadas, los resultados muestran que los PGF del norte no toman los mismos caminos de TA. Esto es importante a tener en cuenta al elaborar acciones de acompañamiento, apoyo y orientación en la implementación de políticas públicas. Los caminos hacia la agroecología fuerte en el norte del país parecen ser múltiples y que por el momento ninguno es el dominante. Además, gracias a diferentes proyectos, los PGF están transitando por diferentes caminos hacia un modo de producir agroecológico. Los pasos que guían estas transformaciones resultan de la interacción de los actores, ya sea entre productores (diálogo entre pares) o por el intercambio con los profesionales en los proyectos que se vienen desarrollando. De estos intercambios surgen acuerdos socio-técnicos y conocimiento asociado (valorizando el saber local con el técnico), que afirman la necesidad de conservar los recursos naturales y favorecer la persistencia de la familia en el campo. La situación generada por la Ley 19.717 y la convocatoria a las organizaciones a participar de la Senda Agroecológica parecen ser dos oportunidades para (re)construir innovaciones de nicho que contribuyan a nuevos regímenes socio-técnicos que permitan transitar hacia una agroecología "fuerte".

NOTAS

1| La convocatoria a proyectos "Senda Agroecológica" fue realizada en 2022. Disponible en: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/noticias/senda-agroecologica-convocatoria-propuestas-transicion-agroecologica.

2| El MGAP a través de la Dirección General de Desarrollo Rural (DGDR) y con el apoyo del Instituto Nacional de Investigación Agropecuaria (INIA) dentro del Programa de Producción Familiar, realizó 2 convocatorias a proyectos de promoción y desarrollo de tecnologías apropiadas para la producción familiar, la primera en el año 2014 y la segunda en el año 2016. https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/convocatorias/tecnologias-para-produccion-familiar.

3| SUL: Secretariado Uruguayo de la Lana, INIA: Instituto Nacional de Investigación Agropecuaria, IPA: Instituto Plan Agropecuario.

REFERENCIAS

ALBICETTE, M. M. *et al*. Co-innovación para promover sistemas ganaderos familiares más sostenibles en Uruguay. Análisis de tres años de cambios en la dimensión social de la sostenibilidad. **Revista Latinoamericana de Estudios Rurales**, v. 1, n. 2, p. 105-136, 2016. Available at: http://www.ceil-conicet.gov.ar/ojs/index.php/revistaalasru/article/view/181 Accessed on: may 2023.

ALONSO-FRADEJAS, A. *et al*. Agroecología Chatarra: la captura corporativa de la agroecología. **Transnational Institute**, 2020. Available at: https://www.tni.org/es/publicaci%C3%B3n/agroecologia-chatarra. Accessed on: may 2023.

ALTIERI, M. A. Agroecology: the science of natural resource management for poor farmers in marginal environments. **Agriculture, Ecosystems and Environment**, v. 93, p. 1-24, 2002. Available at: https://doi.org/10.1016/S0167-8809(02)00085-3

ALTIERI, M.; TOLEDO, V. M. The agroecological revolution of Latin America: rescuing nature, securing food sovereignity and empowering peasants. **The Journal of Peasant Studies**, v. 38, n. 3, p. 587–612, 2011. Available at: https://doi.org/10.1080/03066150.2011.582947

CHIA, E. La agroecología nuevo paradigma para la agricultura familiar y el desarrollo territorial. Contribución del tríptico virtuoso de la innovación, los aprendizajes y la gobernanza. **Revista Cangüé**, 40, p. 10-14, 2018. Available at: http://www.eemac.edu.uy/cangue/?view=projectyid=39:n-40-2018. Accessed on: may 2023.

CLAVEIROLE, C. **La Transition Agroécologique**: défis et enjeux. Le Conseil économique social et environnemental, 2016. Available at: https://www.lecese.fr/travaux-publies/la-transition-agroecologique-defis-et-enjeux. Accessed on: may 2023.

COMPAGNONE, C.; SIGWALT, A. L'espace social du souci des sols: récit et contre-récit d'agriculteurs vendéens en agriculture de conservation. **Natures Sciences Sociétés**, v. 29, n. 4, p. 410–422, 2021. Available at: https://doi.org/10.1051/nss/2022006

DÍAZ, P. El acceso a los campos públicos en la Cuchilla del Fuego, Paysandú, Uruguay. In: DÍAZ. P. (Ed.). **Observatorio de Política de Tierra**, v. 6, p. 73–89, 2021. Psicolibros Waslala.

DIÉGUEZ, F. Estudio de las finalidades de funcionamiento de un grupo de explotaciones familiares ganaderas extensivas. **Agrociencia Uruguay**, v. 18, n. 2, p. 158-148, 2014. Available at: https://doi.org/10.31285/AGRO.18.476

DOGLIOTTI, S. *et al*. Entregable 20 y 27. Protocolos y planes de medición para todas las variables. Proyecto GCP/URU/034/GFF. **Producción ganadera climáticamente inteligente y restauración del suelo en pastizales uruguayos**, 2020. Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/publicaciones/entregable-20-27-ganaderia-clima-protocolos-planes-medicion-para-todas Accessed on: may 2023.

DOTTA, M.; FREIRE, D.; RODRÍGUEZ, N. **El Uruguay Ganadero**. De La explotación primitiva a la crisis actual. Ediciones de la Banda Oriental, 1972, 169p.

DURU, M.; FARES, M.; THEROND, O. **Un cadre conceptuel pour penser maintenant (et organiser demain) la transition agroécologique de l'agriculture dans**. Available at: https://doi.org/10.1684/agr.2014.0691

ELZEN, B. *et al*. (Eds.) **Agroecological transitions**. Changes and breakthroughs inthe making. Wageningen University and Research, 2017. 302 p. Available at: https://doi.org/10.18174/407609

FRANCO, R. *et al*. Ganadería familiar y agroecología. Fortalecimiento de las sociedades pastoriles en Uruguay. **LEISA Revista de Agroecología**, v. 32, n. 4, p. 17–19, 2016. Available at: https://www.leisa-al.org/web/index.php/volumen-32-numero-4/2657-ganaderia-familiar-y-agroecologia-fortalecimiento-de-las-sociedades-pastoriles-en-uruguay. Accessed on: may 2023.

GAZZANO, I.; ACHKAR, M. Conflictos de las transformaciones territoriales: ganaderos frente a la intensificación agraria en Esteros de Farrapos Uruguay. **Revista Iberoamericana de Economía Ecológica**, v. 26, p. 109–121, 2016. Available at: https://hdl.handle.net/20.500.12008/22665. Accessed on: may 2023.

GAZZANO, I.; GÓMEZ PERAZZOLI, A. Agroecology in Uruguay. **Agroecology and Sustainable Food Systems**, v. 41, n 3-4, p. 380–400, 2017. Available at: https://doi.org/10.1080/21683565.2017.1286533

GAZZANO, I. *et al*. Ambiente y crisis en Uruguay. La agroecología como Construcción Contrahegemónica. **Revista de Ciencias Sociales**, v. 34, n. 48, 2020. Available at: https://doi.org/10.26489/rvs.v34i48.1

GEELS, F. W. Technological transitions as Evolutionary Reconfiguration Processes: a multi-level perspective and a case-study. **Research Policy**, v. 31, n. 8-9, p. 1257–1274, 2002. Available at: https://doi.org/10.1016/s0048-7333(02)00062-8

GLIESSMAN, S. R. **Agroecology**. Ecological processes for sustainable agriculture. Chicago, Sleeping Bear Press, 1998. 305p. Available at: https://doi.org/10.2134/jeq1999.00472425002800010046x

GUIBERT, M. *et al*. De Argentina a Uruguay: espacios y actores en una nueva lógica de producción agrícola. **Revista Pampa**, v. 7_sup, p. 13–38, 2011. Available at: https://doi.org/10.14409/pampa.v1i7_sup.3202

HAESBAERT, R. **Des-territorialização e identidade**: a rede gaúcha no Nordeste. Editora da Universidade Federal Fluminense, 1997, 293p. Available at: https://www.eduff.com.br/produto/des-territorializacao-e-identidade-a-rede-gaucha-no-nordeste-e-book-pdf-623. Accessed on: may 2023.

HILL, S. B. Redesigning the food system for sustainability. **Alternatives**, v. 12, p. 32–36, 1985. Available at: https://www.researchgate.net/publication/285538508_Redesigning_the_food_system_for_sustainability#fullTextFileContent. Accessed on: july 2023.

HLPE. **Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition**. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, 2019. Available at: https://www.fao.org/cfs/cfs-hlpe/publications/en. Accessed on: may 2023.

HORLINGS, L. G.; MARSDEN, T. K. Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world.' **Global Environmental Change**, v. 21, n. 2, p. 441–452, 2011. Available at: https://doi.org/10.1016/j.gloenvcha.2011.01.004

KRUEGER, R. A.; CASEY, M. A. **Focus groups**: a practical guide for applied researchers (3rd ed.). Sage Publication, 2000, 215p.

MGAP; DIEA. **Censo General Agropecuario 2011** [Internet]. Montevideo: MGAP; 2014. Available at: https://bit.ly/3Fw8OpU. Accessed on: may 2023.

MGAP; DIEA. **Anuario Estadístico Agropecuario 2021** [Internet]. Montevideo: MGAP; 2021, 261p. Available at: https://bit.ly/3pyPJhp. Accessed on: may 2023.

MIER Y TERÁN, M. *et al*. Bringing agroecology to scale: key drivers and emblematic cases. **Agroecology and Sustainable Food Systems**, v. 42, n. 6, p. 637–665, 2018. Available at: https://doi.org/10.1080/21683565.2018.1443313

MODERNEL, P. *et al*. Identification of beef production farms in the Pampas and Campos area that stand out in economic and environmental performance. **Ecological Indicators**, v. 89, p. 770-755, 2018. Available at: https://doi.org/10.1016/j.ecolind.2018.01.038

ONWUEGBUZIE, A. J. *et al*. Un marco cualitativo para la recolección y análisis de datos en la investigación basada en grupos focales. **Paradigmas**, v. 3, p. 127-157, 2011. Available at: https://dialnet.unirioja.es/servlet/articulo?codigo=3798215. Accessed on: may 2023.

PAOLINO, C.; PITTALUGA, L.; MONDELLI, M. **Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas**. CEPAL – Serie Estudios y Perspectivas – Montevideo – N° 15, 2014, 98p. Available at: https://repositorio.cepal.org/bitstream/handle/11362/36780/S2014255_es.pdf?sequence=1&isAllowed=y. Accessed on: may 2023.

PETERSEN, P.; MONTEIRO, D. **Agroecología o colapso**. Publicaciones Articulação Nacional de Agroecologia. 2021. Available at: https://agroecologia.org.br/2021/01/09/agroecologia-o-colapso/. Accessed on: may 2023.

POSADA RODRIGUEZ, V.; POSADA, N.; RODRIGUEZ, A. Fabricar La Agroecología: lecciones de los proyectos de desarrollo social. **Agrociencia**, v. 24, (NE1), 2020. Available at: https://doi.org/10.31285/agro.24.363

RIBEIRO, C. M. Estudo do modo de vida dos pecuaristas familiares da região da Campanha do Rio Grande do Sul. (Tese de Doutorado) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2009, 303p. Available at: http://hdl.handle.net/10183/17261. Accessed on: may 2023.

ROSSI, V.; FILARDO, V.; CHIA, E. Tipos de Resistencia de la ganadería familiar en el Noroeste Uruguayo. **Eutopía, Revista de Desarrollo Económico Territorial**, v. 15, p. 33–56, 2019. Available at: https://doi.org/10.17141/eutopia.15.2019.3868

TITTONELL, P. Las transiciones agroecológicas: múltiples escalas, niveles y desafíos. **Revista FCA Uncuyo**, v. 51, n. 1, p. 231-246, 2019. Available at: https://revistas.uncu.edu.ar/ojs3/index.php/RFCA/article/view/2448. Accessed on: may 2023.

URUGUAY. Ley 19717/2018 de 21 de diciembre de 2018. Declaración de interés general y creación de una comisión honoraria nacional y plan nacional para el fomento de la producción con bases agroecológicas. C**entro de información oficial IMPO**, 2019. Available at: https://www.impo.com.uy/bases/leyes/19717-2018

VITRY, C.; CHIA, E. Contextualisation d'un instrument et apprentissages pour l'action collective. **Management y Avenir**, v. 83, n. 1, p. 121–141, 2016. Available at: https://doi.org/10.3917/mav.083.0121

Synergies between the Escazú Agreement and the 2030 Agenda on Sustainable Development for Latin America and the Caribbean

Sinergia entre o Acordo de Escazú e a Agenda 2030 sobre o Desenvolvimento Sustentável para a América Latina e o Caribe

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ABSTRACT

This article aims to determine the main synergies between the Escazú Agreement and the 2030 Agenda on sustainable development, which can be exploited for the comprehensive and effective fulfilment of the SDGs. The qualitative approach and the deductive method were applied, considering the principles of environmental democracy and sustainable development as a framework for analysis. The United Nations LinkedSDG application was also used, which performs a semantic correlation analysis between public policy documents and the SDGs. The results show that the pillars of the Escazú Agreement are enablers and accelerators of the 2030 Agenda by creating the conditions for its mainstreaming in decision-making, implementation at the local level and support for actions designed to achieve the SDGs. It is concluded that implementing the Escazú Agreement in coordination with the strategies for fulfilling the SDGs in Latin America is an opportunity for the social legitimisation of public policies.

Keywords: Escazú agreement. SDG. Environmental democracy. Sustainable development. Latin America and the Caribbean.

RESUMO

Este artigo tem como objetivo determinar as principais sinergias entre o Acordo de Escazú e a Agenda 2030 de desenvolvimento sustentável, que podem ser utilizados para o cumprimento integral e efetivo dos ODS. Aplicou-se a abordagem qualitativa e o método dedutivo, tendo como referencial de análise os princípios da democracia ambiental e do desenvolvimento sustentável. Também foi utilizado o aplicativo LinkedSDG das Nações Unidas, que realiza uma análise de correlação semântica entre documentos de

políticas públicas e os ODS. Os resultados mostram que os pilares do Acordo de Escazú são facilitadores e aceleradores da Agenda 2030, ao criar as condições para a sua integração na tomada de decisões, implementação a nível local e apoio a ações destinadas ao cumprimento dos ODS. Conclui-se que implementar o Acordo de Escazú de forma articulada com as estratégias para o cumprimento dos ODS na América Latina é uma oportunidade para a legitimação social das políticas públicas.

Palavras-chave: Acordo de Escazú. ODS. Democracia ambiental. Desenvolvimento sustentável. América Latina e Caribe.

1 INTRODUCTION

The 2030 Agenda is based upon the paradigm of integration and recognises the multidimensional nature of sustainable development challenges and the importance of overcoming the traditional silos that keep the social, economic and environmental sectors isolated (UNDP, 2016). According to Sachs (2010), sustainable development.

> must be understood as one of the greatest ideals that emerged during the last century, perhaps only comparable to the oldest idea of 'social justice'. Both are fundamental values of our time for the expression of collective desires enunciated by humanity, together with peace or democracy. At the same time, nothing ensures that they can be, in fact, possible and achievable (VEIGA, 2010, p. 14).

One of the great challenges in this regard is identifying synergies between agendas, public policies and actions to improve their impact by reducing duplication of effort and interconnected work among actors. This challenge implies, among other things, recognising the territorial context for the application of the 2030 Agenda (CEPAL, 2019a); guaranteeing policy and regulatory coherence (ANTWI-AGEU *et al*., 2017); generating intersectoral correlation and vertical and horizontal institutional coordination (GTLRG, 2016; UN-HABITAT, 2015); establishing long-term objectives (KANIE *et al*., 2017) and promoting the effective participation by the different actors in society, while paying special attention to vulnerable people and groups (UNITED NATIONS, 2017).

Achieving the 2030 Agenda will only be possible if the Sustainable Development Goals (SDGs) are fulfilled in a collective and integrated manner (MORGERA; KULOVESI, 2016) since carrying them out in isolation will lead to global failure, as the experience with the Millennium Development Goals (MDG) has shown. (CORTÉS-PUCH, 2016). The success of environmental governance in the 21st century will depend upon the ability of countries to align specific treaties having objectives associated with a single dimension of development, with other agreements, such as those related to climate change, biodiversity, international trade and human rights, in such a way that multiple benefits can be obtained (FRANCHINI *et al*., 2017).

One of the fundamental purposes of the 2030 Agenda is to achieve inclusive societies; however, a general assessment of the progress of the SDGs in 2019 shows that society's most vulnerable people and groups continue to suffer from situations of inequality and poverty and the response of the countries to face these situations has been slow (UNITED NATIONS, 2019).

Likewise, the 2030 Agenda integrates dimensions of a moral and ethical nature, such as equality, non-discrimination and the protection of fundamental guarantees (FERRERO; LOMA-OSORIO, 2018). In this sense, it shares the vision of intra and intergenerational justice of the Escazú Agreement, whose objective of guaranteeing the full and effective implementation of the rights of access to information, participation and justice in environmental matters is also framed within the context of sustainable development, the guarantee of the right to a healthy environment, peace, solid institutions and efforts for the eradication of poverty.

The Escazú Agreement also contains specific standards for the protection of the human rights of the most vulnerable, such as defenders of environmental human rights, including indigenous and ethnic communities. The regional treaty has as a backdrop the reduction of inequalities (SDG 10) and that the needs of all people are taken into account in making environmental decisions that may affect them (SDG 6, 7, 13, 14 and 15). This ensures the fundamental principle of the 2030 Agenda of leaving no one behind (CEPAL, 2019b).

In this order of ideas, this regional instrument allows progress in eliminating barriers some people face in exercising their rights in conditions of equality and non-discrimination (TORRES, 2018). In addition, it addresses asymmetries in power relationships (BÁRCENA *et al*., 2021), which strengthens the inclusive democracy that is defined in the 2030 Agenda to achieve universal peace within the broader concept of freedom (SDG 16).

The environmental democracy proposed by the Escazú Agreement represents a powerful tool for good governance that contributes to all the SDGs to be attained through the strengthening of informed, participatory, and fair environmental management. For Latin American and Caribbean countries, guaranteeing environmental democracy contributes to making better decisions in harmony with the interests of social actors. It allows its application to be more effective and to strengthen relations between decision-makers and the public through accountability and transparency in public management (CEPAL, 2012). The foregoing is reflected in more suitable, balanced and integrated actions (BÁRCENA; DE MIGUEL, 2016).

This article demonstrates the main synergies between the Escazú Agreement on access to information, public participation and justice in environmental matters in Latin America and the Caribbean and the 2030 Agenda on sustainable development, which can be utilised for the comprehensive and effective implementation of the SDGs. Its approach is presented with a deductive focus, in which the opportunities derived from the interactions between the two agendas can be taken advantage of by the region's countries (LAC) while considering their national circumstances.

To address the foregoing, a qualitative method has been applied, in which, based upon the pillars of environmental democracy developed in the Escazú Agreement, synergies with the 2030 Agenda that enable and/or accelerate compliance with the SDGs have been identified. The main techniques used are the review and documentary analysis of scientific texts and reports from international organisations such as the Economic Commission for Latin America - Eclac and the United Nations-UN. In addition to the above, we utilised the LinkedSDG[1] platform, created by the United Nation, to promote coordination between actors and accelerate the fulfilment of the SDGs. Its operation is based on text mining and allows the identification of semantic relationships between strategies, plans, programs, projects, etc. and the objectives, goals and indicators of the 2030 Agenda.

To address the foregoing, a qualitative method has been applied, in which, based upon the pillars of environmental democracy developed in the Escazú Agreement, synergies with the 2030 Agenda that enable and/or accelerate compliance with the SDGs have been identified. The main techniques used are the review and documentary analysis of scientific texts and reports from international organisations such as the Economic Commission for Latin America - Eclac and the United Nations-UN. In addition to the above, we utilised the LinkedSDG[1] platform, created by the United Nations, to promote coordination between actors and accelerate the fulfilment of the SDGs. Its operation is based on text mining and allows the identification of semantic relationships between strategies, plans, programs, projects, etc. and the objectives, goals and indicators of the 2030 Agenda.

In this way, the reflections presented here are the product of a critical and analytical analysis of governance and international environmental law, which are considered fundamental bases for compliance with the 2030 Agenda and the commitments of the Escazú Agreement.

This article is divided into three sections. The first section addresses the general characteristics of the Escazú Agreement; the second describes the synergies between the two analysed agendas; the third indicates the opportunities under the Escazú Agreement to formulate effective public policies to fulfil the SDGs. It ends with the conclusions resulting from the research.

2 THE ESCAZÚ AGREEMENT: AN INNOVATIVE INSTRUMENT FOR ENVIRONMENTAL GOVERNANCE IN LATIN AMERICA AND THE CARIBBEAN

The Escazú Agreement is the first LAC regional treaty on environmental issues that seeks the full and effective implementation of the rights of access to information, public participation and justice in environmental matters enshrined in Principle 10 of the Rio Declaration on Environment and Development of 1992 (CEPAL, 2018). The Agreement establishes emerging, innovative and necessary measures contributing to protecting the right to live in a healthy environment, achieving sustainable development and reducing environmental conflict in Latin American and Caribbean countries. It is based upon the creation and strengthening of capacities, regional cooperation and the protection of the rights of human rights defenders in environmental matters, taking into consideration that Latin America is the most dangerous region in the world in which to exercise this leadership (MÉDICI, 2018; TOGNOLI, 2018).

This innovative instrument has been highlighted as a historic, ambitious agreement, unprecedented in the region and as a pioneer of its kind (BARRAGÁN-TERÁN *et al*., 2020), not only because of its provisions but also because of the model developed through the negotiation process in which civil society[2], through a Regional Public Mechanism[3], received periodic information on the process and participated in the face-to-face and virtual meetings of the Negotiation Committee (NALEGACH, 2019).

The Escazú Agreement not only stipulates guarantees for the exercise of the right of every person to live in a healthy environment; it also seeks to ensure the enjoyment of all those human rights that are derived from a safe and propitious environment, such as life and health (JIMÉNEZ, 2019). Accordingly, it reflects international environmental law and public international law that develop essential standards of human rights conventions, such as equality and non-discrimination; transparency and accountability; non-regression and progressivity; good faith and the pro-person principles, among others (CEPAL, 2018). The Agreement was opened for signature on September 27, 2018. By 2023, 24 of the 33 countries in the region have signed it, and 15 have ratified it[4].

3 STUDY METHODOLOGY AND DATA PROCESSING

Among the reasons standing out why the MDGs, predecessors of the SDGs, did not have more effective and consistent results in moving towards fair and equitable sustainable development, the failure to consider institutional strengthening as the basis for optimal implementation, the monitoring and achievement of goals; the complexity of formulating indicators for the measurement of progress and the unevenness of the available information systems can be included (ECLAC, 2015). Similarly, there was little civil society involvement, an aspect reflected in the absence of solid governance (SWANSON, 2016).

The foregoing limited the possibility of strengthening relations between society and the State and, therefore, the levels of transparency in public management necessary to achieve the MDGs (VELÁSQUEZ LEAL, 2016). The 2030 Agenda addresses this issue by establishing the need to create effective, accountable, transparent and inclusive institutions at all levels (SDG 16), starting from a participatory approach as the basis for achieving peaceful, inclusive and sustainable societies.

For this to happen, an institutional and regulatory framework is required, which promotes horizontal collaboration and coordination between government structures and sectors, and vertically at global, national and local levels. These are aspects that can only be achieved with the effective involvement of the public (SDG 17) (PNUMA; CEPEI, 2018). In addition, the integrated nature of the SDGs, in which interventions in one area affect results in others, requires the strengthening of appropriate governance measures (BIERMANN *et al*., 2017). This is to prevent a positive interaction from being reversed or that the actions carried out in fulfilment of one SDG restrict, counteract or nullify progress in others (NILSSON *et al*., 2018).

As a starting point to analyse the synergies between the Escazú Agreement and the 2030 Agenda, Figure 1 shows the relationships between the SDGs and the pillars of environmental democracy. Its results are the product of the semantic analysis of the Agreement's final text, in which key concepts related to the 2030 Agenda, its 17 SDGs, 169 goals and 232 indicators were extracted. The SDGs are located in hierarchical order, and the goals' width indicates the most relevant in the Escazú Agreement. Starting with SDG 6, the goal with the greatest interaction is shown.

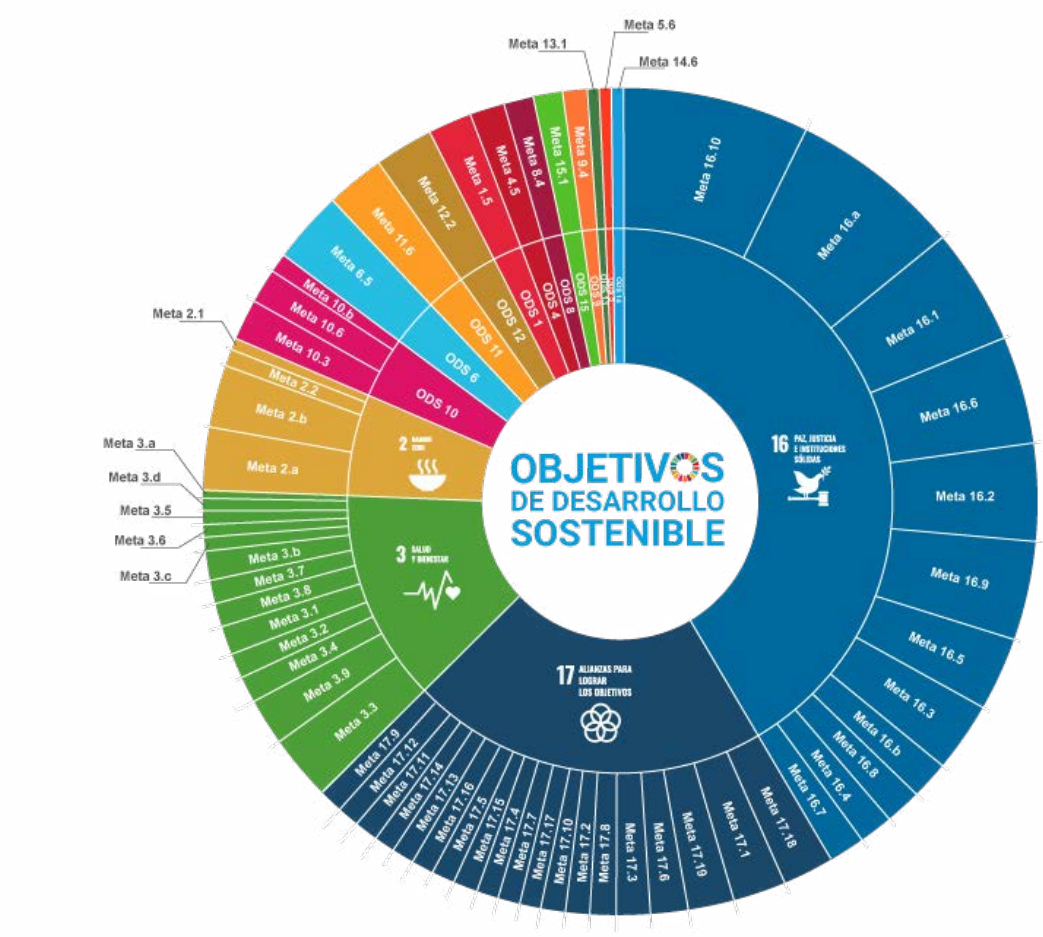

Figure 1 | ODS related to the Escazú Agreement

Source: The authors based on the LinkedSDG tool.

As one can appreciate, the standards of the Escazú Agreement are linked in greater proportion to SDG goals 16 and 17. These establish the need to achieve peace, protect human rights, strengthen governance, regulatory and institutional coherence, and form multi-stakeholder alliances to achieve goals. In particular, the goals on access to public information (16.10 and 17.18) and the protection of fundamental freedoms (16.10) are most related to the Agreement.

Access to information constitutes an essential human right, and its guarantee has become a catalyst for sustainable development in all areas of the SDGs (UNITED NATIONS, 2019; WRI, 2018). Ensuring the production, management and availability of updated, timely and relevant information allows balanced and comprehensive decision-making to comply with the 2030 Agenda. Likewise, promoting public data exchange with non-governmental actors contributes to expanding information coverage and improving its quality and reliability. This component is developed in articles 5 and 6 of the Escazú Agreement.

On the other hand, the "good governance" proposal of the 2030 Agenda, centred on promoting the State of Law/Rule of Law, requires timely, inclusive scenarios and mechanisms and occasions for participation (UNITED NATIONS, 2015). This component is developed in Article 7 of the Escazú Agreement. Likewise, equal access to justice is needed, as well as the independence, impartiality and integrity of the judicial system, as necessary conditions for attaining peaceful and inclusive societies to achieve sustainable development. This issue is addressed in the Declaration of the High-Level Meeting on the Rule of Law, which states that, without access to justice, citizens cannot make their voices heard, exercise their rights or hold decision-makers accountable (UNITED NATIONS, 2012).

To guarantee the right to justice, States must comply with certain principles. These include legality, effectiveness, publicity and transparency, as well as minimum standards such as the dissemination of information about this right; the establishment of equitable, timely and independent procedures; the right to review by a higher instance; and the right to file appeals for the reparation of rights that have been violated, among others (CEPAL, 2016). This component is developed in Article 8 of the Escazú Agreement, which promotes countries guaranteeing a solid structure that allows access to competent, timely, public, transparent and impartial judicial and administrative instances and procedures for protecting the right to a healthy environment and those rights attached to it.

Figure 1 also shows that SDG 3, which seeks to guarantee a healthy life and promote well-being, is strongly related to the Escazú Agreement. This is derived from the interdependence between a risk-free, healthy and sustainable environment and the full exercise of human rights. For example, both the provisions of the Agreement, and the obligation of countries, to progressively establish an updated record of emissions and of transfers of pollutants and residues to the air, water, soil, and subsoil which represent threats to public health, as well as to generate early warnings to take preventive measures and limit possible damage, contribute to this end.

In this way, the indicated interactions show that meeting the goals of the SDGs will not be possible without more transparent governments and more participatory democracies, in which the public and the most vulnerable people are deeply involved in decisions that may affect their environment and in the governance of the natural resources on which their quality of life depends.

This becomes relevant if one considers that planned environmental management, without the broad and effective participation of the public, can have unwanted effects on the population's well-being and may even intensify existing critical situations such as hunger, poverty and inequality.

One aspect of great importance along this track is that when seeking to fulfil the goals and indicators of the SDGs, decision-makers usually implement singular policies that allow them to meet multiple objectives but fail to consider the development of complementary policies that create the conditions by which these are effective, and through which synergies between sectors, institutions and actors are strengthened, contradictory results are avoided, and they can adapt to the changes that societies experience (RIAHI *et al*., 2019).

This is where the Escazú Agreement acquires great relevance since the implementation of its pillars creates a solid architecture based on transparency, complementarity and participation. It seeks coherent, effective, efficient policies that, throughout their life cycle, ensure the full exercise of human rights and fulfil intergenerational responsibilities (PAJÍN; MAYOR ZARAGOZA, 2019) as a fundamental principle of sustainable development.

To overcome the foregoing requires a great effort to transform societies, economies, and the infrastructure and institutions of governance (PNMUA, 2019). For this reason, it is essential to promote spaces for participation and agreement between private actors, academics, civil society, native peoples and vulnerable communities (CONSTANZA *et al*., 2015).

Within this context, environmental democracy constitutes a tool for generating co-benefits to fulfil the 2030 Agenda in LAC. However, the region's countries have not yet considered its potential with sufficient rigour; therefore, their ratification processes have progressed slowly.

The outlook presented in this section can be considered as showing an opportunity for the region, in which the standards of the Escazú Agreement can become tools available to overcome the challenges to democracy and human rights indicated and for the design of public policies, strategies, actions and comprehensive regulations which will allow progress in a positive direction for the two agendas.

4 OPPORTUNITIES UNDER THE ESCAZÚ AGREEMENT FOR INTEGRATED, COHERENT AND ARTICULATED FULFILLMENT OF THE SDGS

This section develops the opportunities derived from the interactions between the Escazú Agreement and the SDGs, which Latin American and Caribbean countries can take advantage of for these agendas' integrated, coherent and articulated fulfilment.

Before addressing the above, it should be noted that despite the efforts made by the countries to conform with the 2030 Agenda, the speed at which measures taken to achieve the SDGs are being implemented is insufficient. (UN ENVIRONMENT, 2019). Latin America and the Caribbean are no strangers to this situation. The SDG Index, as reported by the Center for Sustainable Development Goals for Latin America (Cods), demonstrates that most countries in the region are not advancing positively towards achieving the SDGs. In addition, it indicates that even before the Covid-19 pandemic, which delayed the work of States in achieving different development agendas, the rate of progress towards compliance with the SDGs by 2030 in the region was slow. If this trend were to continue, the goals set could not be achieved even in the next 50 years (CODS, 2020).

Changing the indicated trajectory requires that the region's countries mainstream the 2030 Agenda in their decision-making. To achieve this, leadership must be strengthened at the highest political levels, which would allow efficient and timely legal and institutional formulation, in addition to addressing dilemmas arising out of transversality, such as administrative redundancy and the confrontation of territorial competencies, in a manner that is legitimate and consistent (EUROPEAN COMMISSION, 2019).

To set countries along this path requires the development of catalytic and accelerated measures to guide the management of governments, organisations, society and other actors in a positive direction to achieve the 2030 Agenda, as well as addressing bottlenecks and breaking through sectoral silos that restrict its integrated compliance. The UN developed the Mainstreaming, Acceleration and Support for Public Policies (Maps) approach to contribute to this end. This approach seeks to include the SDG targets in national, subnational and local development plans, as well as in the budgetary distribution of the territories. It seeks to focus resources on priority areas and to direct attention to synergies, exchanges and alliances that can be created to increase the efficiency and effectiveness of interventions and ensure that institutional capacities and resources are sufficient to meet the goals set (UNSDG, 2016).

The Maps approach is based on political coherence and accountability. Accordingly, it recognises the need to articulate development agendas and carry out comprehensive actions with benefits in different dimensions, as well as strengthening the countries' efforts in monitoring, reporting and verifying progress and promoting broad public participation (UNSDG, 2016). At this point, the Escazú Agreement

is key since it creates the enabling conditions for implementing the Maps approach. This is one of the opportunities for integrating these agendas, as described below.

"Mainstreaming" is understood as the application of the 2030 Agenda at the national and local levels. It requires both the horizontal coherence of policies, breaking through the decision-making in sectoral silos, and vertical coherence at the regional, national, and local levels. Access to information and the broad, effective and continuous participation of different social actors are the cornerstones of mainstreaming. Allowing their involvement in the planning, implementation and evaluation of measures leads to true empowerment and commitment to the 2030 Agenda at local levels (SWANSON, 2016).

"Acceleration" refers to focusing national and international resources on priority areas with the greatest potential to generate co-benefits for comprehensive compliance with the SDGs (SWANSON, 2016). Policies of acceleration emphasise strengthening the commitment of sectors and actors within the society to establish alliances, develop monitoring systems, mobilise resources, and address bottlenecks (BOUMA; MARNIE, 2019). This aspect can be achieved with social actors' broad and continuous participation.

The "support" of public policies promotes cooperation among countries to exchange knowledge, experiences and good practices to fulfil development agendas such as the SDGs (BOUMA; MARNIE, 2019). This approach offers an analytical framework that fosters integrated solutions to fulfil the 2030 Agenda.

Another of the opportunities of the Escazú Agreement with respect to the 2030 Agenda is that it makes it possible to achieve the level of legitimacy and confidence necessary to implement development agendas that transcend governmental terms of office and become policies of the state, such as in the case of the SDGs. According to Santofimio Gamboa (2011), the legitimacy of international instruments or agendas can be understood in two ways. The first refers to *formal legitimacy*, that is, these tools meet the requirements established by the States to become legal norms integrated into the legal system and include procedural aspects. The second is *material legitimacy*, which refers to the fact that power is exercised according to the norms of the countries' constitutions.

This condition of legitimacy is not achieved solely through the guarantee of representative democracies and compliance with legal procedures; it requires a high degree of social acceptance throughout the governmental terms, which would allow policies under the 2030 Agenda or the Escazú Agreement to transcend through these periods and become State policies. The foregoing clarifies that the degree of social legitimacy for public policies on compliance with the SDGs can become a form of social control of government performance (BOUMA; MARNIE, 2019).

Achieving this quality is possible through access to information, broad public participation, and transparency and integrity in accountability, as much as in the design of policies and their implementation and monitoring. These aspects can be achieved with the effective implementation of the regional treaty.

Access to disaggregated, quality, accessible, timely and reliable information is essential in order to assess the degree of responsibility and commitment of governments for the implementation of the 2030 Agenda in aspects such as the allocation and use of public spending and the relevance, effectiveness, efficiency and sustainability of a planned, ongoing or implemented policy initiative for compliance with the SDGs (OECD, 2019).

Likewise, guaranteeing the broad and effective participation of the public in the design of public policies, actions, strategies, and regulations regarding the 2030 Agenda improves transparency and trust in decision-making. This reinforces the confidence society has in their governments and allows

the achievement of more efficient results by understanding the links between the measures developed, the needs and interests of the population, the capacity of the institutions and the results obtained.

The foregoing represents a fundamental issue in that the measures that are developed in compliance with the SDGs must be taken in comprehension of the local context and priorities and contribute to the mobilisation of resources, the provision of innovative and efficient solutions (OECD, 2019) and encourage governments to governments to set more ambitious goals and be accountable for their commitment, difficulties and challenges. As stated in the United Nations Secretary-General's report on the progress of the SDGs in 2019:

> The 2030 Agenda can only become effective by adopting an approach that takes into account the whole of society, with non-governmental agents that assume as their own the paradigm shift that the Agenda entails, (to) harmonise their own systems with the Sustainable Development Goals, participate actively in implementation efforts and become promoters of continuous improvement (UNITED NATIONS, 2019, p. 31).

Finally, the Escazú Agreement makes it possible to apply the "national ownership" approach of the 2030 Agenda. Even though the scope of the SDGs is global, their implementation considers the different realities, capacities and levels of development of countries and respects their policies and priorities. Under this principle, the importance of the regional, subregional and national levels is recognised for effectively translating sustainable development policies into concrete measures locally (NACIONES UNIDAS, 2015).

In this sense, to fulfil the SDGs, it becomes essential to break the centralism of governments in decision-making and to interact with the various actors and levels of governance at the national and local levels based on participatory processes. This is achieved through the balance between top-down and bottom-up processes in decision-making, as well as in formulating and implementing policies, strategies and regulations (NILSSON, 2018).

Achieving a balance between these processes mentioned above calls for transforming the traditional way of making decisions, based upon the 'descending' direction, which begins from the "global" to reach the "local," into an 'ascending' management flow, which starts from the local level and reaches to the global. Through this means, as Tognoli (2018) points out, local governments, based upon the exercise of public participation, have the potential to become the basic infrastructure to achieve efficiency, effectiveness, sustainability and legitimacy of intervention to achieve sustainable development.

5 CONCLUSIONS

The synergies between the Escazú Agreement and the 2030 Agenda facilitate compliance with the SDGs. They establish the path for their implementation, strengthening good governance and approaches to human rights, inclusion, participation, transparency and justice (BARRAGÁN-TERÁN *et al*., 2020). They also promote greater integration of the different worldviews and cultural patterns present in the region, which is an aspect that has been considered one of the challenges faced by these countries in integrating the concept of sustainable development into decision-making.

The main opportunities derived from the effective implementation of the standards of the Escazú Agreement to fulfil the 2030 Agenda in Latin American and Caribbean countries are the legitimisation of public policies for sustainable development, the mainstreaming, acceleration and support for compliance with the SDGs and the localisation or territorialisation of climate commitments and the 2030 Agenda which allows their national ownership.

From the perspective of the legitimacy of public policies, the standards of the Escazú Agreement, by guaranteeing that all interested parties participate in the cycle of policies for the fulfilment of these agendas, as well as in the monitoring, reporting and verification of their progress, contribute to strategic decision-making, improve the links between policies and results. They also strengthen accountability and increase transparency and trust in the institutions charged with implementing the SDGs.

In this same order of ideas, the Escazú Agreement is a catalytic policy for the 2030 Agenda by favouring the mainstreaming of the SDGs in public policies and decisions taken at the national and local levels through the effective involvement of the public, the generation and dissemination of information and the strengthening of trust in governments. This contributes to the implementation of efficient policies which generate multiple benefits.

This study provides a first approach to the synergies between the Escazú Agreement and the 2030 Agenda. It represents an opportunity for more detailed analyses to evaluate how the environmental democracy proposed in the treaty mentioned above can accelerate the implementation of specific goals of the SDGs. In addition, it opens the possibility to link to the analysis of other development agendas, such as the Paris Agreement and the Convention on Biological Diversity.

NOTES

1| Available at http://linkedsdg.apps.officialstatistics.org/#/

2| For the purposes of the participation of civil society in the negotiation process of the Agreement, the word “public” has been adopted, which refers to "any natural or legal person or organized in community forms."

3| Created for the purposes of of keeping informed those interested in the Agreement, allowing their participation and contributing to the transparency of the negotiation process. Available online at: Disponible en línea en: https://www.lacp10.org/mecanismo-publico-regional.

4| Information reporte don the Principle 10 Observatory website of Cepal on July 2023 (https://www.cepal.org/es/acuerdodeescazu).

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REFERENCES

ANTWI-AGEU, P.; DOUGILL, A.; STRINGER, L. Assessing Coherence between Sector Policies and Climate Compatible Development: opportunities for triple wins. **Sustainability**, v. 9, n. 11, p. 21-30, 2017. Available at: https://doi.org/10.3390/su9112130.

BÁRCENA, A.; MIGUEL, C. Más ciudadanía para el desarrollo sostenible. **Notas de la Cepal N° 88**. Comisión Económica para América Latina y el Caribe, 2016. Available at: https://www.cepal.org/es/articulos/2016-mas-ciudadania-desarrollo-sostenible. Accessed on: mar. 25. 2022.

BÁRCENA, A.; TORRES, V.; MUÑOZ AVILA, L. **El Acuerdo de Escazú sobre democracia ambiental y su relación con la Agenda 2030 para el Desarrollo Sostenible**. Editorial Universidad del Rosario, 2021. Available at: https://editorial.urosario.edu.co/catalog/product/view/id/6465/s/gpd-el-acuerdo-de-escazu-sobre-democracia-ambiental-y-su-relacion-con-la-agenda-2030-para-el-desarrollo-sostenible-9789587847543/category/667/. Accessed on: mar. 25. 2022.

BARRAGÁN-TERÁN, D.; MUÑOZ-ÁVILA, L.; SANHUEZA-E, A. La importancia de la democracia ambiental para la implementación de los Objetivos de Desarrollo Sostenible en América Latina y el Caribe. En VARGAS-CHAVES, I.;

GÓMEZ-REY, A.; IBÁÑEZ-ELAM, A. **Escuela de derecho ambiental**. Homenaje a Gloria Amparo Rodríguez, p. 77-108. Editorial Universidad del Rosario, 2020.

BIERMANN, F. *et al*. Global goal setting for improving national governance and policy. En KANIE, N.; BIERMANN, F. **Governing Through Goals**, p. 75-97. The MIT Press, 2017.

BOUMA, G.; MARNIE, S. **Summary of main findings from SDG mainstreaming, acceleration and policy support mission reports**. Programa de Naciones Unidas para el Desarrollo, 2019. Available at: https://www.undp.org/eurasia/publications/summary-findings-sdg-mainstreaming-acceleration-and-policy-support-mission-reports. Accessed on: jan. 21. 2023.

CENTRO DE LOS OBJETIVOS DE DESARROLLO SOSTENIBLE PARA AMÉRICA LATINA (CODS). **Índice ODS 2019 para América Latina y el Caribe**, 2020. Available at: https://cods.uniandes.edu.co/indice-ods/. Accessed on: dec. 17. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). D**eclaración sobre la aplicación del principio 10 de la Declaración de Río sobre el Medio Ambiente y el Desarrollo**, 2012. Available at: https://www.cepal.org/sites/default/files/pages/files/686xxxv-principio_10-esp.pdf. Accessed on: dec. 10. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **América Latina y el Caribe**: una mirada al futuro desde los Objetivos de Desarrollo del Milenio. Informe regional de monitoreo de los Objetivos de Desarrollo del Milenio en América Latina y el Caribe, 2015. Available at: https://repositorio.cepal.org/bitstream/handle/11362/38923/S1500709_es.pdf. Accessed on: dec. 10. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Sociedad, derechos y medio ambiente**. Estándares internacionales de derechos humanos aplicables al acceso a la información, a la participación pública y al acceso a la justicia, 2016. Available at: https://www.cepal.org/es/publicaciones/40735-sociedad-derechos-medio-ambiente-estandares-internacionales-derechos-humanos. Accessed on: nov. 5. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe**, 2018. Available at: https://repositorio.cepal.org/bitstream/handle/11362/43595/S2200798_es.pdf. Accessed on: june 12. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Territorialización de la Agenda 2030**. Documento Anexo N. 1. Observatorio Regional de Planificación para el Desarrollo de América Latina y el Caribe, 2019a. Available at: https://igualdad.cepal.org/es/digital-library/territorializacion-de-la-agenda-2030-documento-anexo-ndeg-1. Accessed on: july 12. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). I**nforme de avance cuatrienal sobre el progreso y los desafíos regionales de la Agenda 2030 para el Desarrollo Sostenible en América Latina y el Caribe**, 2019b. Available at: https://www.cepal.org/es/publicaciones/44551-informe-avance-cuatrienal-progreso-desafios-regionales-la-agenda-2030-desarrollo. Accessed on: july 12. 2022.

COMISIÓN EUROPEA. **Avances en la Acción Climática de América Latina**: contribuciones nacionalmente determinadas al 2019. Programa Euroclima+, Dirección General de Desarrollo y Cooperación – EuropeAid, 2019. Available at: https://www.cepal.org/sites/default/files/pdf_estudio_avances_agosto_2019_-_21-8v2.pdf. Accessed on: july 23. 2023.

CONSTANZA, R. *et al*. An Overarching Goal for the UN Sustainable Development Goals. **Solutions**, v. 5, n. 4, p. 13-16, 2015. Available at: https://thesolutionsjournal.com/. Accessed on: sept. 17. 2022.

CORTÉS-PUNCH, M. Los ODS y el Acuerdo de París: herramientas para coordinar globalmente el desarrollo sostenible. **Tiempo de Paz**, n. 120, p. 32-43, 2016. Available at: https://revistatiempodepaz.org/revista-120/. Accessed on: nov. 7. 2022.

FRANCHINI, M.; VIOLA, E.; BARROS-PLATIAU, A. F. Los desafíos del Antropoceno: de la política ambiental internacional hacia la gobernanza global. **Ambiente & Sociedade**, v. XX, n. 3, p. 179-206, 2017. Available at: http://dx.doi.org/10.1590/1809-4422asoc214v2022017

GLOBAL TASKFORCE OF LOCAL AN REGIONAL GOVERNMENTS (GTLRG). **Guía para la localización de los ODS**: implementación y monitoreo subnacional, 2016. Available at: https://ods.gub.uy/images/GUIA-GLOBAL-TASKFORCE---ODS-Subnacional-1.pdf. Accessed on: nov. 7. 2022.

JIMÉNEZ, H. El Acuerdo de Escazú y el derecho de acceso a la información dan a luz una nueva jurisprudencia. **Revista Derecho del Estado**, n. 44, p. 385-396, 2019. Available at: https://doi.org/10.18601/01229893.n44.14

KANIE, N. *et al*. Introduction: global governance through goal setting. En KANIE, N.; BIERMANN, F. **Governing Through Goals**, p.1-27. The MIT Press, 2017.

MÉDICI, G. El Acuerdo Escazú: la implementación del Principio 10 de Río en América Latina y El Caribe. **Revista Catalana de Dret Ambiental**, v. IX, n. 1, p. 1-66, 2018. Available at: https://doi.org/10.17345/rcda2412

MORGERA, E.; KULOVESI, K. Global governance: problem shifting in the Anthropocene and the limits of international law. En RAKHYUN, K.; H. van ASSELT. **Research Handbook on International Law and Natural Resources**, p. 473–495. Edward Elgar Publishing, 2016.

NACIONES UNIDAS. **Declaración de Rio sobre el Medio Ambiente y el Desarrollo**. Departamento de Asuntos Económicos y Sociales División de Desarrollo Sostenible, 1992. Available at: https://www.un.org/spanish/esa/sustdev/agenda21/riodeclaration.htm. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Declaración de la reunión de alto nivel de la Asamblea General sobre el estado de derecho en los planos nacional e internacional**. Asamblea General de las Naciones Unidas, 2012. Available at: https://www.un.org/es/ga/president/68/settingthestage/5hrrol.shtml. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Resolución A/70/L.1. Transformar nuestro mundo**: la Agenda 2030 para el Desarrollo Sostenible. Asamblea General de las Naciones Unidas, 2015. Available at: https://unctad.org/system/files/official-document/ares70d1_es.pdf. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Progresos realizados para lograr los Objetivos de Desarrollo Sostenible los Objetivos de Desarrollo Sostenible**. Edición especial. Consejo Económico y Social de Naciones Unidas, 2019. Available at: https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--ES.pdf. Accessed on: july 12. 2022.

NALEGACH, C. Acuerdo de Escazú: quienes pierden sin su protección. **Cuadernos Médico Sociales**, v. 59, n. 1, p. 55–62, 2019. Available at: https://cuadernosms.cl/index.php/cms/article/view/196. Accessed on: july 26. 2022.

NILSSON, M. *et al*. Mapping interactions between the sustainable development goals: lessons learned and ways forward. **Sustainability Science**, v. 13, p. 1489-1503, 2018. Available at: https://doi.org/10.1007/s11625-018-0604-z

ORGANIZACIÓN DE LAS NACIONES UNIDAS PARA LA EDUCACIÓN, LA CIENCIA Y LA CULTURA (UNESCO). **El acceso a la información se actualiza en el marco de los indicadores del ODS**, 2019. Available at: https://www.unesco.org/es/articles/el-acceso-la-informacion-se-actualiza-en-el-marco-de-los-indicadores-del-ods. Accessed on: july 27. 2022.

ORGANIZACIÓN PARA LA COOPERACIÓN Y EL DESARROLLO ECONÓMICO (OCDE). **Governance as an SDG accelerator**. Country experiences and tools. OECD Publishing, Paris, 2019. Available at: https://doi.org/10.1787/0666b085-en

OSORIO, G. F. L. Los Objetivos de Desarrollo Sostenible y el Acuerdo de París. **Tiempos de Paz**, n. 128, p. 24-34, 2018. Available at: https://revistatiempodepaz.org/revista-120/. Accessed on: nov. 7. 2022.

PAJÍN, L.; MAYOR ZARAGOZA, F. Conexión global y local de la Agenda 2030. **Tiempo de Paz**, n. 132, p. 7-11, 2019. Available at: https://revistatiempodepaz.org/revista-132/. Accessed on: july 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA). **El desarrollo sostenible en la práctica**: la aplicación de un enfoque integrado en América Latina y el Caribe, 2016. Available at: https://wedocs.unep.org/20.500.11822/21542. Accessed on: june 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA) Y CEPEI. **Gobernanza ambiental y la Agenda 2030**: avances y buenas prácticas en América Latina y el Caribe, 2018. Available at: https://wedocs.unep.org/20.500.11822/26756. Accessed on: june 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA). **Resumen para responsables de formular políticas**: perspectivas del medio ambiente mundial Geo 6. Planeta sano, personas sanas, 2019. Available at: https://www.unep.org/es/resources/perspectivas-del-medio-ambiente-mundial-6. Accessed on: june 27. 2022.

RIAHI, K. *et al*. **Linking Climate and Sustainable Development**. Policy insights from national and global pathways. International Institute for Applied Systems Analysis (IIASA), 2019. Available at: https://pure.iiasa.ac.at/id/eprint/16235/1/CD-Links-for-web_final_November_2019.pdf. Accessed on: june 27. 2022.

SANTOFIMIO GAMBOA, J. **Procedimientos administrativos y tecnología**. Universidad Externado de Colombia, 2011.

SWANSON, D. **Transversalización de la Agenda 2030 para el Desarrollo Sostenible**. Guía de referencia para los Equipos de las Naciones Unidas en los países. Grupo de las Naciones Unidas para el Desarrollo, 2016. Available at: https://unsdg.un.org/sites/default/files/UNDG-Mainstreaming-the-2030-Agenda-Reference-Guide_Spanish-clean.pdf. Accessed on: june 14. 2022.

TOGNOLI, J. Desafíos de la democracia ambiental en el marco de la firma del Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe (Acuerdo de Escazú). **Anuario en Relaciones Internacionales**, v. 1, n. 13, 2018. Available at: http://sedici.unlp.edu.ar/handle/10915/98883. Accessed on: june 14. 2022.

TORRES, V. Acuerdo de Escazú: avanzando en la construcción de sociedades más transparentes, participativas, justas y sostenibles. **Puentes entre el Comercio y el Desarrollo Sostenible**, [s. l.], v. 19, n. 4, p. 4–7, 2018. Available at: https://search-ebscohost-com.ez.urosario.edu.co/login.aspx?direct=true&AuthType=ip&db=bth&AN=130640053&lang=es&site=eds-live&scope=site. Accessed on: june 14. 2022.

UN-HABITAT. **International guidelines on urban and territorial planning**, 2015. Available at: https://unhabitat.org/international-guidelines-on-urban-and-territorial-planning. Accessed on: june 14. 2022.

UNITED NATIONS. **Your Right to Build a Sustainable Future**: the Aarhus Convention, its Protocol on PRTRs and the Sustainable Convention, its Protocol on PRTRs and the Sustainable. Economic and Social Council, 2017. Available at: https://unece.org/fileadmin/DAM/env/pp/mop6/HLS/ECE_MP.PP_2017_18-_ECE_MP.PRTR_2017_4_E.pdf. Accessed on: sept. 25. 2021.

UNITED NATIONS. **SDG Acceleration Actions**. Available at: https://sdgs.un.org/partnerships/action-networks/acceleration-actions, 2019. Accessed on: sept. 25. 2021.

UNITED NATIONS SUSTAINABLE DEVELOPMENT GROUP (UNSDG). **MAPS**: a common approach to the UNDG's policy support to the SDGs. An update on implementation. United Nations Sustainable Development Group, 2016. Available at: https://www.un.org/ecosoc/sites/www.un.org.ecosoc/files/files/en/qcpr/doco-summary-brief-on-maps-march2016.pdf. Accessed on: july 26. 23

VEIGA, J. **Desenvolvimento Sustentável**: o desafio do século XXI. Rio de Janeiro: Garamond, 2010.

VELÁSQUEZ LEAL, L**. Oportunidades para la implementación de prácticas de buena gobernanza y rendición de cuentas en el seguimiento y fiscalización de los Objetivos de Desarrollo Sostenible en América Latina**, 2016. Available at: https://www.eurosai.org/en/databases/products/Oportunidades-para-la-implementacion-de-practicas-de-buena-gobernanza-y-rendicion-de-cuentas-en-el-seguimiento-y-fiscalizacion-de-los-Objetivos-de-Desarrollo-Sostenible-en-America-Latina/. Accessed on: june 14. 2022.

WORD RESOURCES INSTITUTE. **Collective Actions on Climate and Sustainable Development through the Open Government Partnership**. Open Government Partnership, 2018. Available at: https://www.opengovpartnership.org/wp-content/uploads/2017/10/Climate-Issue-Brief.pdf. Accessed on: june 14. 2022.

Sinergias entre el Acuerdo de Escazú y la Agenda 2030 sobre Desarrollo Sostenible para América Latina y el Caribe

Synergies between the Escazú Agreement and the 2030 Agenda on Sustainable Development for Latin America and the Caribbean

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ARTICLE- VARIA

RESUMEN

Este artículo tiene como objetivo determinar las principales sinergias entre el Acuerdo de Escazú y la Agenda 2030 sobre desarrollo sostenible, que pueden ser aprovechadas para el cumplimiento integral y efectivo de los ODS. Se aplicó el enfoque cualitativo y el método deductivo, considerando como marco de análisis los principios de la democracia ambiental y del desarrollo sostenible. También se utilizó el aplicativo LinkedSDG de las Naciones Unidas que realiza un análisis de correlación semántica entre documentos de política pública y los ODS. Los resultados muestran que los pilares del Acuerdo de Escazú son habilitantes y aceleradores de la Agenda 2030, al crear las condiciones para su transversalización en la toma de decisiones, implementación a escala local y soporte a las acciones diseñadas para el cumplimiento de los ODS. Se concluye que implementar el Acuerdo de Escazú de forma articulada con las estrategias para el cumplimiento de los ODS en América Latina, es una oportunidad para la legitimación social de políticas públicas.

Palabras clave: Acuerdo de Escazú. ODS. Democracia ambiental. Desarrollo sostenible. América Latina y el Caribe.

ABSTRACT

This article aims to determine the main synergies between the Escazú Agreement and the 2030 Agenda on sustainable development, which can be exploited for the comprehensive and effective fulfilment of the SDGs. The qualitative approach and the deductive method were applied, considering the principles of environmental democracy and sustainable development as a framework for analysis. The United Nations LinkedSDG application was also used, which performs a semantic correlation analysis between

public policy documents and the SDGs. The results show that the pillars of the Escazú Agreement are enablers and accelerators of the 2030 Agenda by creating the conditions for its mainstreaming in decision-making, implementation at the local level and support for actions designed to achieve the SDGs. It is concluded that implementing the Escazú Agreement in coordination with the strategies for fulfilling the SDGs in Latin America is an opportunity for the social legitimisation of public policies

Keywords: Escazú agreement. SDG. Environmental democracy. Sustainable development. Latin America and the Caribbeane.

1 INTRODUCCIÓN

La Agenda 2030 se basa en el paradigma de la integración y reconoce la naturaleza multidimensional de los desafíos del desarrollo sostenible y la importancia de superar los silos tradicionales que mantienen aislados los sectores social, económico y ambiental (PNUD, 2016). De acuerdo con Sachs (2010), el desarrollo sostenible

> debe ser entendido como uno de los más grandes ideales surgidos en el siglo pasado, tal vez sólo comparable a la más antigua idea de "justicia social". Ambos son valores fundamentales de nuestra época por exprimir deseos colectivos enunciados por la humanidad, al lado de la paz o la democracia. Al mismo tiempo, nada asegura que puedan ser, de hecho, posibles y realizables (VEIGA, 2010, p. 14).

Uno de los grandes retos al respecto, consiste en identificar sinergias entre agendas, políticas públicas y acciones para mejorar su impacto, a través de la reducción de la duplicidad de esfuerzos y del trabajo articulado entre actores. Este desafío, implica, entre otros, reconocer el contexto territorial para aplicar la Agenda 2030 (CEPAL, 2019a); garantizar la coherencia política y normativa (ANTWI-AGEU *et al*., 2017); generar articulación intersectorial y coordinación institucional vertical y horizontal (GTLRG, 2016; UN-HABITAT, 2015); establecer objetivos de largo plazo (KANIE *et al*., 2017) y promover la participación efectiva de los diferentes actores de la sociedad, con especial atención en las personas y los grupos vulnerables (UNITED NATIONS, 2017).

Lograr la Agenda 2030 sólo será posible si se cumplen los Objetivos de Desarrollo Sostenible (ODS) de manera colectiva e integrada (MORGERA; KULOVESI, 2016) ya que hacerlo de forma aislada conducirá al fracaso global como lo mostró la experiencia con los Objetivos de Desarrollo del Milenio – ODM (CORTÉS-PUCH, 2016). El éxito de la gobernanza ambiental en el siglo XXI depende de la capacidad de los países para alinear tratados específicos con objetivos asociados a una sola dimensión del desarrollo, con otros acuerdos, como los que tienen que ver con el cambio climático, la biodiversidad, el comercio internacional y los derechos humanos, de tal manera que se obtengan múltiples beneficios (FRANCHINI *et al*., 2017).

Uno de los propósitos fundamentales de la Agenda 2030 es lograr sociedades inclusivas; sin embargo, un balance general sobre el progreso de los ODS en 2019, muestra que las personas y grupos más vulnerables de la sociedad siguen sufriendo situaciones de desigualdad y pobreza y la respuesta de los países para afrontarlas ha sido lenta (NACIONES UNIDAS, 2019).

De igual modo, la Agenda 2030 integra dimensiones de corte moral y ético, tales como la igualdad, la no discriminación y la protección de las garantías fundamentales (FERRERO; LOMA-OSORIO, 2018). En este sentido, comparte la visión de la justicia intra e intergeneracional del Acuerdo de Escazú, cuyo objetivo de garantizar la implementación plena y efectiva de los derechos de acceso a la información, a la participación y a la justicia en asuntos ambientales también se enmarca en el contexto del desarrollo sostenible, la garantía del derecho al ambiente sano, la paz, las instituciones sólidas y en los esfuerzos para erradicar la pobreza.

El Acuerdo de Escazú también contiene estándares específicos para la protección de los derechos humanos de los más vulnerables, como las personas defensoras de derechos humanos ambientales, incluyendo a las comunidades indígenas y étnicas. El tratado regional tiene como trasfondo reducir las desigualdades (ODS 10) y que las necesidades de todas las personas sean tomadas en cuenta en las decisiones ambientales que puedan afectarlas (ODS 6, 7, 13, 14 y 15), asegurando de esta manera, el principio fundamental de la Agenda 2030 de no dejar a nadie atrás (CEPAL, 2019b).

En este orden de ideas, este instrumento regional permite avanzar en la eliminación de las barreras que enfrentan algunas personas para ejercer sus derechos en condiciones de igualdad y no discriminación (TORRES, 2018), además de hacer frente a las asimetrías en las relaciones de poder (BÁRCENA *et al*., 2021), lo cual fortalece la democracia inclusiva que se define en la Agenda 2030 para lograr la paz universal, dentro del concepto más amplio de libertad (ODS 16).

La democracia ambiental que propone el Acuerdo de Escazú representa una poderosa herramienta de buena gobernanza que contribuye a alcanzar todos los ODS a partir del fortalecimiento de la gestión ambiental informada, participativa y justa. Para los países latinoamericanos y caribeños, garantizar la democracia ambiental contribuye a la toma de mejores decisiones armonizadas con los intereses de los actores sociales y permite que su aplicación sea más eficaz y se fortalezcan las relaciones entre los tomadores de decisión y el público, a través de la rendición de cuentas y la transparencia en la gestión pública (CEPAL, 2012). Lo anterior, se refleja en acciones más adecuadas, equilibradas e integradas (BÁRCENA; DE MIGUEL, 2016).

Este artículo muestra las principales sinergias que existen entre el Acuerdo de Escazú sobre el acceso a la información, la participación pública y la justicia en asuntos ambientales en América Latina y el Caribe y la Agenda 2030 sobre desarrollo sostenible, que pueden ser aprovechadas para el cumplimiento integral y efectivo de los ODS. Su abordaje se presenta desde un enfoque deductivo, en el que las oportunidades derivadas de las interacciones entre las dos agendas pueden ser aprovechadas por los países de la región (ALyC), teniendo en cuenta sus circunstancias nacionales.

Para abordar lo anterior, se aplicó un método cualitativo, en el que a partir de los pilares de la democracia ambiental desarrollados en el Acuerdo de Escazú, se identificaron las sinergias con la Agenda 2030 que habilitan y/o aceleran el cumplimiento de los ODS. Cómo técnicas se utilizaron principalmente la revisión y el análisis documental de textos científicos e informes de organismos internacionales como la Comisión Económica para América Latina – Cepal y la Organización de las Naciones Unidas – ONU. Además de lo anterior, se utilizó la plataforma LinkedSDG[1], creada por las Naciones Unidas como una herramienta para promover la articulación entre actores y acelerar el cumplimiento de los ODS. Su funcionamiento se basa en la minería de textos y permite identificar la relación semántica entre estrategias, planes, programas, proyectos, etc., con los objetivos, metas e indicadores de la Agenda 2030.

De esta manera, las reflexiones que aquí se presentan son producto de un análisis crítico y analítico desde la gobernanza y el derecho ambiental internacional, los cuáles se consideran como asuntos fundamentales para el cumplimiento de la Agenda 2030 y los compromisos del Acuerdo de Escazú.

Este artículo se divide en tres secciones. La primera de ellas, aborda las características generales del Acuerdo de Escazú; la segunda describe las sinergias que existen entre las dos agendas analizadas y la tercera muestra las oportunidades del Acuerdo de Escazú para formular políticas públicas efectivas para el cumplimiento de los ODS. Finaliza con las conclusiones producto de la investigación.

2 EL ACUERDO DE ESCAZÚ: UN INSTRUMENTO INNOVADOR PARA LA GOBERNANZA AMBIENTAL EN AMÉRICA LATINA Y EL CARIBE

El Acuerdo de Escazú es el primer tratado regional en temas ambientales de ALyC que busca la implementación plena y efectiva de los derechos de acceso a la información, la participación pública y la justicia en asuntos ambientales consagrados en el Principio 10 de la Declaración de Río sobre el Medio Ambiente y el Desarrollo de 1992 (CEPAL, 2018). El Acuerdo establece medidas emergentes, novedosas y necesarias para contribuir a la protección del derecho a vivir en un ambiente sano, alcanzar el desarrollo sostenible y reducir la conflictividad ambiental en los países latinoamericanos y caribeños, a partir de la creación y el fortalecimiento de las capacidades, la cooperación regional y la protección de los derechos de las personas defensoras de los derechos humanos en asuntos ambientales, teniendo en consideración que América Latina es la región más peligrosa del mundo para ejercer este liderazgo (MÉDICI, 2018; TOGNOLI, 2018).

Este innovador instrumento ha sido destacado como un acuerdo histórico, ambicioso, sin antecedentes en la región y pionero en su tipo (BARRAGÁN-TERÁN *et al*., 2020), no solo por sus disposiciones, sino por el modelo desarrollado en el proceso de negociación, en el que la sociedad civil[2], a través del Mecanismo Público Regional[3], recibió información periódicamente sobre el proceso y participó en las reuniones presenciales y virtuales del Comité de Negociación (NALEGACH, 2019).

El Acuerdo de Escazú no solo brinda garantías procedimentales para el ejercicio del derecho de toda persona a vivir en un ambiente sano; también busca asegurar el disfrute de todos aquellos derechos humanos que se desprenden de un entorno seguro y propicio, como la vida y la salud (JIMÉNEZ, 2019). Por lo tanto, considera principios del derecho internacional ambiental y del derecho internacional público que desarrollan estándares esenciales de un convenio de derechos humanos, como la igualdad y no discriminación; la transparencia y rendición de cuentas; la no regresión y progresividad; la buena fe y el principio pro-persona, entre otros (CEPAL, 2018). El Acuerdo fue abierto para su firma el 27 de septiembre de 2018. Al 2023, 24 de los 33 países de la región lo han firmado y 15 lo han ratificado[4].

3 LOS ESTÁNDARES DEL ACUERDO DE ESCAZÚ Y LA AGENDA 2030

Dentro de las razones por las cuales los ODM, predecesores de los ODS, no tuvieron resultados más prósperos y homogéneos para avanzar hacia el desarrollo sostenible justo y equitativo, se destaca la falta de considerar el fortalecimiento institucional como base para una óptima implementación, seguimiento y cumplimiento de las metas; la complejidad para formular indicadores para medir el progreso y la precariedad de los sistemas de información disponibles (CEPAL, 2015). De igual forma, hubo poco involucramiento de la sociedad civil, aspectos que se reflejan en la ausencia de una gobernanza sólida (SWANSON, 2016).

Lo anterior, limitó la posibilidad de fortalecer las relaciones entre sociedad y Estado y por tanto, los niveles de transparencia en la gestión pública para alcanzar los ODM (VELÁSQUEZ LEAL, 2016). La Agenda 2030 aborda este asunto al establecer la necesidad de crear instituciones eficaces, responsables, transparentes e inclusivas en todos los niveles (ODS 16), a partir de un enfoque participativo como base para lograr sociedades pacíficas, inclusivas y sostenibles.

Para ello, se requiere de un marco institucional y normativo, que propicie la colaboración y coordinación horizontal entre estructuras de gobierno y sectores, y vertical entre las escalas global, nacional y local; aspectos que solo se pueden lograr con el involucramiento efectivo del público (ODS 17) (PNUMA; CEPEI, 2018). Además, el carácter integrado de los ODS, en el que las intervenciones en un área afectan los resultados en otras, hace necesario el fortalecimiento de medidas de gobernanza apropiadas (BIERMANN *et al*., 2017) . Esto con el fin de que eviten que una interacción positiva se vea revertida o que las acciones desarrolladas en cumplimiento de un ODS restrinjan, contrarresten o anulen el progreso en otros (NILSSON *et al*., 2018).

Como punto de partida para analizar las sinergias entre el Acuerdo de Escazú y la Agenda 2030, en la Figura 1 se muestran las relaciones entre los ODS y los pilares de la democracia ambiental. Sus resultados son producto del análisis semántico del texto final del Acuerdo, en el que se extrajeron conceptos clave vinculados a la Agenda 2030, sus 17 ODS, 169 metas y 232 indicadores. Los ODS se ubican en orden jerárquico y el ancho de las metas indica las más relevantes en el Acuerdo de Escazú. A partir del ODS 6 se muestra la meta que mayor interacción.

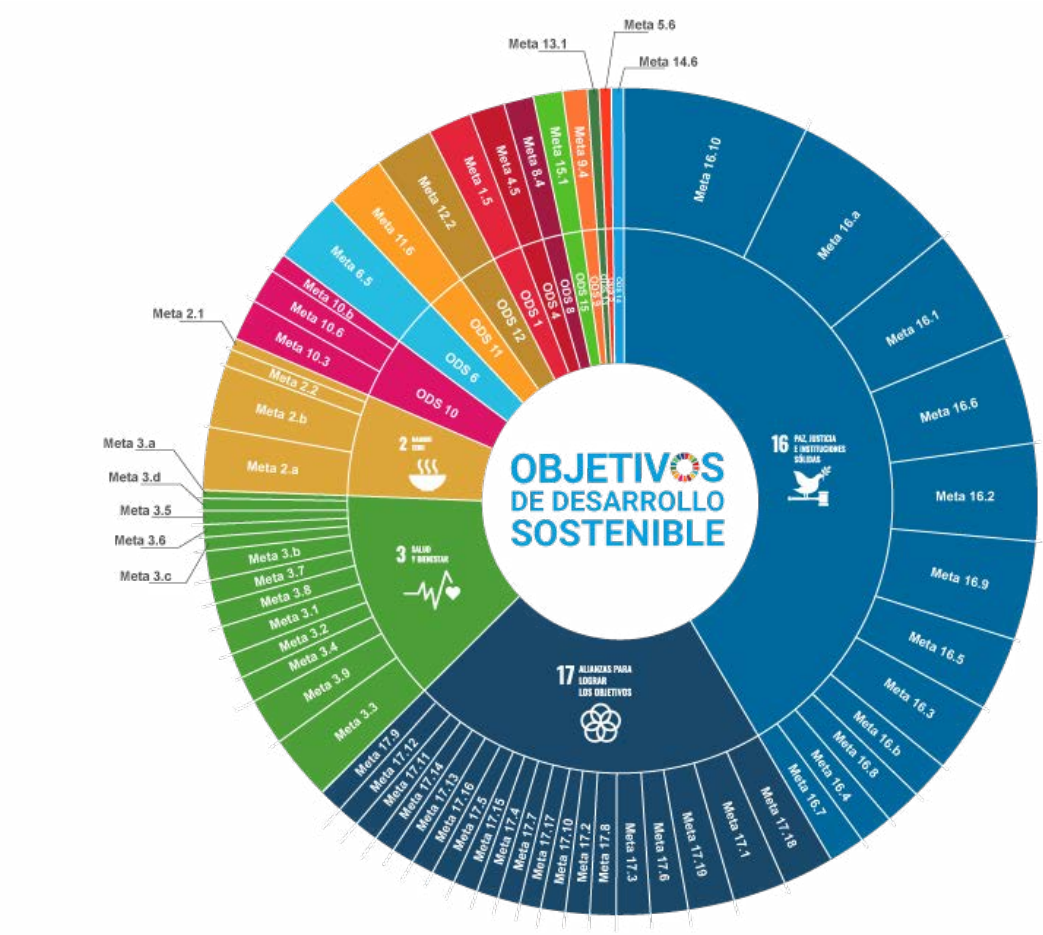

Figura 1 | ODS relacionados con el Acuerdo de Escazú

Fuente: Las autoras a partir de la herramienta LinkedSDG.

Como puede apreciarse, los estándares del Acuerdo de Escazú se vinculan en mayor proporción con las metas de los ODS 16 y 17, que establecen la necesidad de alcanzar la paz, la protección de los derechos humanos, fortalecer la gobernabilidad, la coherencia normativa e institucional y las alianzas entre múltiples partes interesadas para alcanzar los objetivos. Particularmente, las metas sobre el acceso a información pública (16.10 y 17.18), así como la protección de las libertades fundamentales (16.10) son las que más se relacionan con el Acuerdo.

El acceso a la información constituye un derecho humano indispensable y su garantía se convierte en catalizador para el desarrollo sostenible en todas las áreas de los ODS (UNITED NATIONS, 2019; WRI, 2018). Asegurar la producción, la gestión y disponibilidad de información actualizada, oportuna y relevante permite la toma de decisiones balanceada e integral para el cumplimiento de la Agenda 2030. Así mismo, promover el intercambio de datos públicos con actores no gubernamentales, contribuye a ampliar la cobertura de la información, el mejoramiento de su calidad y confiabilidad. Este componente se desarrolla en los artículos 5 y 6 del Acuerdo de Escazú.

De otra parte, la propuesta de la Agenda 2030 del "buen gobierno", centrada en la promoción del Estado de Derecho y el imperio de la ley, requiere escenarios y mecanismos oportunos, incluyentes e incidentes de participación (NACIONES UNIDAS, 2015). Este componente se desarrolla en el artículo 7 del Acuerdo de Escazú. Asimismo, se necesita del acceso igualitario a la justicia, además de la independencia, imparcialidad e integridad del sistema judicial, como condición necesaria para alcanzar sociedades pacíficas e inclusivas para el logro del desarrollo sostenible. Este asunto es abordado en la Declaración de la Reunión de Alto Nivel sobre el Estado de Derecho, al señalar que, sin acceso a la justicia, las y los ciudadanos no pueden hacer oír su voz, ejercer sus derechos o hacer que los tomadores de decisión rindan cuentas (NACIONES UNIDAS, 2012).

Para la garantía del derecho a la justicia, los Estados deben cumplir con ciertos principios como la legalidad, la efectividad, la publicidad y la transparencia, así como con estándares mínimos como la difusión de información sobre este derecho; el establecimiento de procedimientos equitativos, oportunos e independientes; el derecho a la revisión por una instancia superior; a interponer recursos para la reparación de los derechos que han sido vulnerados, entre otros (CEPAL, 2016). Este componente se desarrolla en el artículo 8 del Acuerdo de Escazú al promover que los países garanticen una estructura sólida que permita acceder a instancias y procedimientos judiciales y administrativos competentes, oportunos, públicos, transparentes e imparciales para la protección del derecho al ambiente sano y aquellos derechos conexos a este.

La Figura 1 también muestra que el ODS 3, que busca garantizar la vida sana y promover el bienestar, presenta una relación fuerte con el Acuerdo de Escazú. Lo anterior se deriva de la dependencia que existe entre un ambiente sin riesgos, saludable y sostenible para el ejercicio pleno de los derechos humanos. Por ejemplo, tanto las disposiciones del Acuerdo, como la obligación de los países de establecer progresivamente un registro actualizado de emisiones y transferencia de contaminantes y residuos al aire, agua, suelo y subsuelo que representen amenazas a la salud pública, así como generar alertas tempranas para tomar medidas de prevención y limitar eventuales daños, contribuyen a este fin.

De este modo, las interacciones señaladas, muestran que cumplir las metas de los ODS no será posible sin gobiernos más transparentes y democracias más participativas, en las que el público y las personas más vulnerables estén profundamente involucrados en las decisiones que puedan afectar su entorno y en la gobernanza de los recursos naturales de los cuales depende su calidad de vida.

Ello resulta relevante si se considera que una gestión ambiental planificada sin la participación amplia y efectiva del público, puede tener efectos no deseados en el bienestar de la población e incluso intensificar situaciones críticas existentes como el hambre, la pobreza y la desigualdad.

Un aspecto de gran importancia en este camino, es que al tratar de cumplir las metas e indicadores de los ODS, los tomadores de decisión usualmente implementan políticas individuales que les permitan cumplir múltiples objetivos y no consideran el desarrollo de políticas complementarias que creen las condiciones para que estas sean efectivas, se fortalezcan las sinergias entre sectores, instituciones y actores, se eviten resultados contradictorios y se adapten a los cambios que experimentan las sociedades (RIAHI *et al*., 2019).

Es aquí donde el Acuerdo de Escazú adquiere gran relevancia, pues la implementación de sus pilares crea una arquitectura sólida basada en la transparencia, la complementariedad y la participación. Busca que las políticas sean coherentes, eficaces, eficientes y a lo largo de su ciclo de vida se asegure el ejercicio pleno de los derechos humanos y se cumplan las responsabilidades intergeneracionales (PAJÍN; MAYOR ZARAGOZA, 2019) como principio fundamental del desarrollo sostenible.

Superar lo anterior requiere de un gran esfuerzo para transformar las sociedades, las economías, la infraestructura y las instituciones de gobernanza (PNUMA, 2019), por esta razón resulta fundamental

promover espacios de participación y concertación entre actores privados, académicos, sociedad civil, pueblos originarios y comunidades vulnerables (CONSTANZA *et al*., 2015).

Bajo este contexto, la democracia ambiental constituye una herramienta para generar co-beneficios para el cumplimiento de la Agenda 2030 en ALyC; no obstante, los países de la región aún no han considerado su potencial con el suficiente rigor y por tanto, sus procesos de ratificación han avanzado de forma lenta.

El panorama presentado en esta sección puede ser considerado como una oportunidad para la región, en la que los estándares del Acuerdo de Escazú se convierten en herramientas para superar los desafíos de la democracia y los derechos humanos señalados y diseñar políticas públicas, estrategias, acciones y normas integrales que permitan avanzar en una dirección positiva en las dos agendas.

4 OPORTUNIDADES DEL ACUERDO DE ESCAZÚ PARA EL CUMPLIMIENTO INTEGRADO, COHERENTE Y ARTICULADO DE LOS ODS

En esta sección se desarrollan las oportunidades que se derivan de las interacciones entre el Acuerdo de Escazú y los ODS, que pueden ser aprovechadas por los países latinoamericanos y caribeños para el cumplimiento integrado, coherente y articulado de estas agendas.

Antes de abordar lo anterior, es preciso señalar que a pesar de los esfuerzos realizados por los países para cumplir la Agenda 2030, la velocidad a la cual se están implementando las medidas para alcanzar los ODS es insuficiente (ONU AMBIENTE, 2019). América Latina y el Caribe no es ajena a esta situación. El Índice de los ODS reportado por el Centro de los Objetivos de Desarrollo Sostenible para América Latina (Cods) muestra que, la mayoría de países de la región no están avanzando en una dirección positiva para alcanzar los ODS; además, indica que incluso antes de la pandemia por la Covid-19, que ha retrasado el trabajo de los Estados para el logro de diferentes agendas de desarrollo, el ritmo de avance para el cumplimiento de los ODS a 2030 en la región era lento y de continuar con esa tendencia las metas trazadas no se podrán alcanzar ni siquiera en los próximos 50 años (CODS, 2020).

Cambiar la trayectoria señalada requiere que los países de la región transversalicen la Agenda 2030 en la toma de decisiones. Para lograrlo, es imperativo fortalecer el liderazgo en los niveles políticos más altos, que permita la articulación legal e institucional eficiente y oportuna, además de abordar dilemas derivados de la transversalidad, como la redundancia administrativa y el enfrentamiento de competencias territoriales, de manera legítima y congruente (COMISIÓN EUROPEA, 2019).

Situar a los países en este camino, demanda el desarrollo de medidas catalíticas y aceleradoras que orienten la gestión de los gobiernos, las organizaciones, la sociedad y los demás actores en una dirección positiva para el logro de la Agenda 2030, así como abordar los cuellos de botella y romper los silos sectoriales que restringen su cumplimiento integrado. Para contribuir a este fin, la ONU desarrolló el enfoque Transversalización, Aceleración y Apoyo a Políticas Públicas (Maps por sus siglas en inglés), que busca que las metas de los ODS sean incluidas dentro de los planes de desarrollo nacionales, subnacionales y locales, así como en la distribución presupuestal de los territorios; focalizar recursos en áreas prioritarias y prestar atención en las sinergias, intercambios y alianzas que se pueden crear para aumentar la eficiencia y eficacia de las intervenciones y asegurar que las capacidades y los recursos institucionales sean suficientes para el cumplimiento de las metas trazadas (UNSDG, 2016).

El enfoque Maps se fundamenta en la coherencia política y en la rendición de cuentas, por ello reconoce la necesidad de articular agendas de desarrollo y llevar a cabo acciones integrales con beneficios en diferentes dimensiones, así como fortalecer los esfuerzos de los países para el monitoreo, reporte y verificación del progreso y promover la participación amplia del público (UNSDG, 2016). Es allí en

donde el Acuerdo de Escazú resulta clave, pues crea las condiciones habilitantes para la implementación del enfoque Maps, siendo esta una de las oportunidades para la implementación integrada de estas agendas, como se describe a continuación.

La "transversalización" se entiende como la aplicación de la Agenda 2030 en los niveles nacional y local, lo que requiere tanto de la coherencia horizontal de las políticas, es decir romper la toma de decisiones en silos sectoriales; como vertical en los niveles regional, nacional, local. El acceso a la información y la participación amplia, efectiva y continua de los diferentes actores sociales son las piedras angulares de la transversalización, al permitir su involucramiento en la planificación, implementación y evaluación de medidas, lo que lleva a un verdadero empoderamiento y compromiso de la Agenda 2030 en los ámbitos locales (SWANSON, 2016).

La "aceleración" se refiere a la focalización de los recursos nacionales e internacionales en las áreas prioritarias y con mayor potencial de generar co-beneficios para el cumplimiento integral de los ODS (SWANSON, 2016). Las políticas aceleradoras prestan especial atención en el fortalecimiento del compromiso de los sectores y actores de la sociedad para establecer alianzas, desarrollar sistemas de monitoreo, movilizar recursos y abordar cuellos de botella (BOUMA; MARNIE, 2019), aspecto que puede lograrse con la participación amplia y continua de los actores sociales.

El "apoyo" a las políticas públicas promueve la cooperación entre países para el intercambio de conocimiento, experiencias y buenas prácticas para el cumplimiento de agendas de desarrollo como los ODS (BOUMA; MARNIE, 2019). Este enfoque ofrece un marco analítico que promueve soluciones integradas para el cumplimiento de la Agenda 2030.

Otra de las oportunidades del Acuerdo de Escazú de cara a la Agenda 2030, es que permite lograr el nivel de legitimidad y confianza necesario para implementar agendas de desarrollo que trascienden los períodos de gobierno y se constituyen en políticas de Estado, como el caso de los ODS. Según Santofimio Gamboa (2011), la legitimidad de los instrumentos o agendas internacionales puede ser entendida desde dos vías. La primera se refiere a la *legitimidad formal*, es decir que dichas herramientas cumplen con los requisitos establecidos por los Estados para constituirse en normas jurídicas que se integran al ordenamiento y comprenden aspectos procedimentales. La segunda es la *legitimidad material*, que se refiere a que el poder es ejercido de acuerdo con los postulados de las Constituciones de los países.

Esta condición no se alcanza únicamente a través de la garantía de democracias representativas y el cumplimiento de procedimientos jurídicos; requiere un alto grado de aceptación social a lo largo de los periodos de gobierno, que permita que las políticas sobre la Agenda 2030 o del Acuerdo de Escazú trasciendan a través de estos y se conviertan en políticas de Estado. Lo anterior lleva a establecer que el grado de legitimidad social de las políticas públicas para el cumplimiento de los ODS se convierte en una forma de control social del desempeño de los gobiernos (BOUMA; MARNIE, 2019).

Lograr esta cualidad es posible a través del acceso a la información, la participación amplia del público y la transparencia e integridad en la rendición de cuentas, tanto en el diseño de políticas como en su implementación y seguimiento; aspectos que pueden lograrse con la implementación efectiva del tratado regional.

El acceso a la información desglosada, de calidad, accesible, oportuna y fiable es esencial para evaluar el grado de responsabilidad y compromiso de los gobiernos para la implementación de la Agenda 2030, en aspectos como la asignación y uso del gasto público y la pertinencia, eficacia, eficiencia y sostenibilidad de una iniciativa política prevista, en curso o implementada para el cumplimiento de los ODS (OCDE, 2019).

Así mismo, garantizar la participación amplia y efectiva del público en el diseño de políticas públicas, acciones, estrategias y normas sobre la Agenda 2030, mejora los niveles de transparencia y confianza en

la toma de decisiones. Esto refuerza la credibilidad de la sociedad en los gobiernos y les permite lograr resultados más eficientes al comprender los vínculos entre las medidas desarrolladas, las necesidades e intereses de la población, la capacidad de las instituciones y los resultados obtenidos.

Lo anterior, representa un asunto fundamental para que las medidas que se desarrollen en cumplimiento de los ODS comprendan el contexto y las prioridades locales, contribuyan a la movilización de recursos, la provisión de soluciones innovadoras y eficientes (OCDE, 2019) y exhorten a los gobiernos a establecer metas más ambiciosas y rendir cuentas de su compromiso, dificultades y retos. Como se establece en el informe del Secretario General de las Naciones Unidas sobre el progreso de los ODS en 2019.

> La Agenda 2030 sólo puede hacerse efectiva adoptando un enfoque que tenga en cuenta a toda la sociedad, con agentes no gubernamentales que asuman como propio el cambio de paradigma que trae aparejado la Agenda, armonicen sus propios sistemas con los Objetivos de Desarrollo Sostenible, participen activamente en los esfuerzos de implementación y se conviertan en promotores de una mejora continua (NACIONES UNIDAS, 2019, p. 31).

Finalmente, el Acuerdo de Escazú posibilita aplicar el enfoque de apropiación nacional de la Agenda 2030. A pesar de que el alcance de los ODS es global, su implementación considera las diferentes realidades, capacidades y niveles de desarrollo de los países, respetando sus políticas y prioridades. Bajo este principio, se reconoce la importancia de los niveles regional, subregional y nacional para traducir efectivamente las políticas de desarrollo sostenible en medidas concretas a nivel local (NACIONES UNIDAS, 2015).

En este sentido, para cumplir los ODS resulta fundamental romper el centralismo de los gobiernos en la toma de decisiones e interactuar con los diversos actores y escalas de gobernanza en los niveles nacional y local, a partir de procesos participativos, lo cual se logra a través del balance entre los procesos top-down y bottom-up en la toma de decisiones, así como en la formulación e implementación de políticas, estrategias y normas (NILSSON, 2018).

Lograr el equilibrio entre los procesos señalados, insta a transformar la forma tradicional de tomar decisiones, basada en el sentido 'descendente', que parte de lo global para llegar a lo local, por un flujo de gestión 'ascendente', que parta de lo local hasta llegar a lo global, en la medida en que como lo señala Tognoli, (2018), son los gobiernos locales, a partir del ejercicio de la participación pública, los que tienen el potencial para convertirse en la infraestructura básica para lograr la eficiencia, efectividad, sostenibilidad y legitimidad de las intervenciones para alcanzar el desarrollo sostenible.

5 CONCLUSIONES

Las sinergias entre el Acuerdo de Escazú y la Agenda 2030 son facilitadores del cumplimiento de los ODS, al establecer el camino para su implementación, fortalecer la buena gobernanza y los enfoques de derechos humanos, inclusión, participación, transparencia y justicia (BARRAGÁN-TERÁN *et al*., 2020), así como promover una mayor integración de las distintas cosmovisiones y patrones culturales presentes en la región, aspecto que ha sido considerado como uno de los retos que enfrentan estos países para integrar el concepto de desarrollo sostenible a la toma de decisiones.

Las principales oportunidades que se derivan de la implementación efectiva de los estándares del Acuerdo de Escazú para cumplir la Agenda 2030 en los países latinoamericanos y caribeños, son la legitimación de políticas públicas para el desarrollo sostenible; la transversalización, aceleración y el apoyo para el cumplimiento de los ODS y la localización o territorialización de los compromisos climáticos y la Agenda 2030 que permita su apropiación nacional.

Desde la perspectiva de la legitimidad de las políticas públicas, los estándares del Acuerdo de Escazú, al garantizar que todas las partes interesadas participen en el ciclo de las políticas para el cumplimiento de estas agendas, así como en el monitoreo, reporte y verificación de su progreso, contribuye a la toma de decisiones estratégicas, mejora los vínculos entre las políticas y los resultados, además de fortalecer la rendición de cuentas y aumentar los niveles de transparencia y confianza en las instituciones que tienen a su cargo la implementación de los ODS.

En este mismo orden de ideas, el Acuerdo de Escazú es una política catalítica de la Agenda 2030, al favorecer la transversalización de los ODS en las políticas públicas y en las decisiones a nivel nacional y local, a través del involucramiento efectivo del público, la generación y divulgación de información y el fortalecimiento de la confianza en los gobiernos; lo que contribuye a implementar políticas eficientes que generen múltiples beneficios.

Este estudio es una primera aproximación a las sinergias entre el Acuerdo de Escazú y la Agenda 2030 y representa una oportunidad para análisis más detallados que evalúen cómo la democracia ambiental propuesta en el citado tratado puede acelerar la implementación de metas específicas de los ODS. Además, abre la posibilidad para vincular al análisis otras agendas de desarrollo como el Acuerdo de París y el Convenio de Diversidad Biológica.

NOTA

1| Disponible en http://linkedsdg.apps.officialstatistics.org/#/

2| Para efectos de la participación de la sociedad civil en el proceso de negociación del Acuerdo se adoptó la palabra público que se refiere a “cualquier persona natural o jurídica u organizada en formas comunitarias.

3| Creado con el fin de mantener informado a los interesados en el Acuerdo, permitir su participación y contribuir a la transparencia del proceso de negociación. Disponible en línea en: https://www.lacp10.org/mecanismo-publico-regional.

4| Información reportada en el sitio web del Observatorio del Principio 10 de la Cepal el 25 de julio de 2023 (https://www.cepal.org/es/acuerdodeescazu).

Este artículo es uno de los productos resultado del proyecto de investigación “Perspectivas de la implementación de la Agenda 2030 y sus Objetivos de Desarrollo Sostenible en Colombia a la luz del Acuerdo de París sobre cambio climático” financiado por el Ministerio de Ciencia, Tecnología e Innovación de Colombia.

REFERENCIAS

ANTWI-AGEU, P.; DOUGILL, A.; STRINGER, L. Assessing Coherence between Sector Policies and Climate Compatible Development: opportunities for triple wins. **Sustainability**, v. 9, n. 11, p. 21-30, 2017. Available at: https://doi.org/10.3390/su9112130.

BÁRCENA, A.; MIGUEL, C. Más ciudadanía para el desarrollo sostenible. **Notas de la Cepal N° 88**. Comisión Económica para América Latina y el Caribe, 2016. Available at: https://www.cepal.org/es/articulos/2016-mas-ciudadania-desarrollo-sostenible. Accessed on: mar. 25. 2022.

BÁRCENA, A.; TORRES, V.; MUÑOZ AVILA, L. **El Acuerdo de Escazú sobre democracia ambiental y su relación con la Agenda 2030 para el Desarrollo Sostenible**. Editorial Universidad del Rosario, 2021. Available at: https://editorial.urosario.edu.co/catalog/product/view/id/6465/s/gpd-el-acuerdo-de-escazu-sobre-democracia-ambiental-y-su-relacion-con-la-agenda-2030-para-el-desarrollo-sostenible-9789587847543/category/667/. Accessed on: mar. 25. 2022.

BARRAGÁN-TERÁN, D.; MUÑOZ-ÁVILA, L.; SANHUEZA-E, A. La importancia de la democracia ambiental para la implementación de los Objetivos de Desarrollo Sostenible en América Latina y el Caribe. En VARGAS-CHAVES, I.;

GÓMEZ-REY, A.; IBÁÑEZ-ELAM, A. **Escuela de derecho ambiental**. Homenaje a Gloria Amparo Rodríguez, p. 77-108. Editorial Universidad del Rosario, 2020.

BIERMANN, F. *et al*. Global goal setting for improving national governance and policy. En KANIE, N.; BIERMANN, F. **Governing Through Goals**, p. 75-97. The MIT Press, 2017.

BOUMA, G.; MARNIE, S. **Summary of main findings from SDG mainstreaming, acceleration and policy support mission reports**. Programa de Naciones Unidas para el Desarrollo, 2019. Available at: https://www.undp.org/eurasia/publications/summary-findings-sdg-mainstreaming-acceleration-and-policy-support-mission-reports. Accessed on: jan. 21. 2023.

CENTRO DE LOS OBJETIVOS DE DESARROLLO SOSTENIBLE PARA AMÉRICA LATINA (CODS). **Índice ODS 2019 para América Latina y el Caribe**, 2020. Available at: https://cods.uniandes.edu.co/indice-ods/. Accessed on: dec. 17. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). D**eclaración sobre la aplicación del principio 10 de la Declaración de Río sobre el Medio Ambiente y el Desarrollo**, 2012. Available at: https://www.cepal.org/sites/default/files/pages/files/686xxxv-principio_10-esp.pdf. Accessed on: dec. 10. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **América Latina y el Caribe**: una mirada al futuro desde los Objetivos de Desarrollo del Milenio. Informe regional de monitoreo de los Objetivos de Desarrollo del Milenio en América Latina y el Caribe, 2015. Available at: https://repositorio.cepal.org/bitstream/handle/11362/38923/S1500709_es.pdf. Accessed on: dec. 10. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Sociedad, derechos y medio ambiente**. Estándares internacionales de derechos humanos aplicables al acceso a la información, a la participación pública y al acceso a la justicia, 2016. Available at: https://www.cepal.org/es/publicaciones/40735-sociedad-derechos-medio-ambiente-estandares-internacionales-derechos-humanos. Accessed on: nov. 5. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe**, 2018. Available at: https://repositorio.cepal.org/bitstream/handle/11362/43595/S2200798_es.pdf. Accessed on: june 12. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). **Territorialización de la Agenda 2030**. Documento Anexo N. 1. Observatorio Regional de Planificación para el Desarrollo de América Latina y el Caribe, 2019a. Available at: https://igualdad.cepal.org/es/digital-library/territorializacion-de-la-agenda-2030-documento-anexo-ndeg-1. Accessed on: july 12. 2022.

COMISIÓN ECONÓMICA PARA AMÉRICA LATINA Y EL CARIBE (CEPAL). I**nforme de avance cuatrienal sobre el progreso y los desafíos regionales de la Agenda 2030 para el Desarrollo Sostenible en América Latina y el Caribe**, 2019b. Available at: https://www.cepal.org/es/publicaciones/44551-informe-avance-cuatrienal-progreso-desafios-regionales-la-agenda-2030-desarrollo. Accessed on: july 12. 2022.

COMISIÓN EUROPEA. **Avances en la Acción Climática de América Latina**: contribuciones nacionalmente determinadas al 2019. Programa Euroclima+, Dirección General de Desarrollo y Cooperación – EuropeAid, 2019. Available at: https://www.cepal.org/sites/default/files/pdf_estudio_avances_agosto_2019_-_21-8v2.pdf. Accessed on: july 23. 2023.

CONSTANZA, R. *et al*. An Overarching Goal for the UN Sustainable Development Goals. **Solutions**, v. 5, n. 4, p. 13-16, 2015. Available at: https://thesolutionsjournal.com/. Accessed on: sept. 17. 2022.

CORTÉS-PUNCH, M. Los ODS y el Acuerdo de París: herramientas para coordinar globalmente el desarrollo sostenible. **Tiempo de Paz**, n. 120, p. 32-43, 2016. Available at: https://revistatiempodepaz.org/revista-120/. Accessed on: nov. 7. 2022.

FRANCHINI, M.; VIOLA, E.; BARROS-PLATIAU, A. F. Los desafíos del Antropoceno: de la política ambiental internacional hacia la gobernanza global. **Ambiente & Sociedade**, v. XX, n. 3, p. 179-206, 2017. Available at: http://dx.doi.org/10.1590/1809-4422asoc214v2022017

GLOBAL TASKFORCE OF LOCAL AN REGIONAL GOVERNMENTS (GTLRG). **Guía para la localización de los ODS**: implementación y monitoreo subnacional, 2016. Available at: https://ods.gub.uy/images/GUIA-GLOBAL-TASKFORCE---ODS-Subnacional-1.pdf. Accessed on: nov. 7. 2022.

JIMÉNEZ, H. El Acuerdo de Escazú y el derecho de acceso a la información dan a luz una nueva jurisprudencia. **Revista Derecho del Estado**, n. 44, p. 385-396, 2019. Available at: https://doi.org/10.18601/01229893.n44.14

KANIE, N. *et al*. Introduction: global governance through goal setting. En KANIE, N.; BIERMANN, F. **Governing Through Goals**, p.1-27. The MIT Press, 2017.

MÉDICI, G. El Acuerdo Escazú: la implementación del Principio 10 de Río en América Latina y El Caribe. **Revista Catalana de Dret Ambiental**, v. IX, n. 1, p. 1-66, 2018. Available at: https://doi.org/10.17345/rcda2412

MORGERA, E.; KULOVESI, K. Global governance: problem shifting in the Anthropocene and the limits of international law. En RAKHYUN, K.; H. van ASSELT. **Research Handbook on International Law and Natural Resources**, p. 473–495. Edward Elgar Publishing, 2016.

NACIONES UNIDAS. **Declaración de Rio sobre el Medio Ambiente y el Desarrollo**. Departamento de Asuntos Económicos y Sociales División de Desarrollo Sostenible, 1992. Available at: https://www.un.org/spanish/esa/sustdev/agenda21/riodeclaration.htm. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Declaración de la reunión de alto nivel de la Asamblea General sobre el estado de derecho en los planos nacional e internacional**. Asamblea General de las Naciones Unidas, 2012. Available at: https://www.un.org/es/ga/president/68/settingthestage/5hrrol.shtml. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Resolución A/70/L.1. Transformar nuestro mundo**: la Agenda 2030 para el Desarrollo Sostenible. Asamblea General de las Naciones Unidas, 2015. Available at: https://unctad.org/system/files/official-document/ares70d1_es.pdf. Accessed on: july 12. 2022.

NACIONES UNIDAS. **Progresos realizados para lograr los Objetivos de Desarrollo Sostenible los Objetivos de Desarrollo Sostenible**. Edición especial. Consejo Económico y Social de Naciones Unidas, 2019. Available at: https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--ES.pdf. Accessed on: july 12. 2022.

NALEGACH, C. Acuerdo de Escazú: quienes pierden sin su protección. **Cuadernos Médico Sociales**, v. 59, n. 1, p. 55–62, 2019. Available at: https://cuadernosms.cl/index.php/cms/article/view/196. Accessed on: july 26. 2022.

NILSSON, M. *et al*. Mapping interactions between the sustainable development goals: lessons learned and ways forward. **Sustainability Science**, v. 13, p. 1489-1503, 2018. Available at: https://doi.org/10.1007/s11625-018-0604-z

ORGANIZACIÓN DE LAS NACIONES UNIDAS PARA LA EDUCACIÓN, LA CIENCIA Y LA CULTURA (UNESCO). **El acceso a la información se actualiza en el marco de los indicadores del ODS**, 2019. Available at: https://www.unesco.org/es/articles/el-acceso-la-informacion-se-actualiza-en-el-marco-de-los-indicadores-del-ods. Accessed on: july 27. 2022.

ORGANIZACIÓN PARA LA COOPERACIÓN Y EL DESARROLLO ECONÓMICO (OCDE). **Governance as an SDG accelerator**. Country experiences and tools. OECD Publishing, Paris, 2019. Available at: https://doi.org/10.1787/0666b085-en

OSORIO, G. F. L. Los Objetivos de Desarrollo Sostenible y el Acuerdo de París. **Tiempos de Paz**, n. 128, p. 24-34, 2018. Available at: https://revistatiempodepaz.org/revista-120/. Accessed on: nov. 7. 2022.

PAJÍN, L.; MAYOR ZARAGOZA, F. Conexión global y local de la Agenda 2030. **Tiempo de Paz**, n. 132, p. 7-11, 2019. Available at: https://revistatiempodepaz.org/revista-132/. Accessed on: july 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA). **El desarrollo sostenible en la práctica**: la aplicación de un enfoque integrado en América Latina y el Caribe, 2016. Available at: https://wedocs.unep.org/20.500.11822/21542. Accessed on: june 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA) Y CEPEI. **Gobernanza ambiental y la Agenda 2030**: avances y buenas prácticas en América Latina y el Caribe, 2018. Available at: https://wedocs.unep.org/20.500.11822/26756. Accessed on: june 27. 2022.

PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE (PNUMA). **Resumen para responsables de formular políticas**: perspectivas del medio ambiente mundial Geo 6. Planeta sano, personas sanas, 2019. Available at: https://www.unep.org/es/resources/perspectivas-del-medio-ambiente-mundial-6. Accessed on: june 27. 2022.

RIAHI, K. *et al*. **Linking Climate and Sustainable Development**. Policy insights from national and global pathways. International Institute for Applied Systems Analysis (IIASA), 2019. Available at: https://pure.iiasa.ac.at/id/eprint/16235/1/CD-Links-for-web_final_November_2019.pdf. Accessed on: june 27. 2022.

SANTOFIMIO GAMBOA, J. **Procedimientos administrativos y tecnología**. Universidad Externado de Colombia, 2011.

SWANSON, D. **Transversalización de la Agenda 2030 para el Desarrollo Sostenible**. Guía de referencia para los Equipos de las Naciones Unidas en los países. Grupo de las Naciones Unidas para el Desarrollo, 2016. Available at: https://unsdg.un.org/sites/default/files/UNDG-Mainstreaming-the-2030-Agenda-Reference-Guide_Spanish-clean.pdf. Accessed on: june 14. 2022.

TOGNOLI, J. Desafíos de la democracia ambiental en el marco de la firma del Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe (Acuerdo de Escazú). **Anuario en Relaciones Internacionales**, v. 1, n. 13, 2018. Available at: http://sedici.unlp.edu.ar/handle/10915/98883. Accessed on: june 14. 2022.

TORRES, V. Acuerdo de Escazú: avanzando en la construcción de sociedades más transparentes, participativas, justas y sostenibles. **Puentes entre el Comercio y el Desarrollo Sostenible**, [s. l.], v. 19, n. 4, p. 4–7, 2018. Available at: https://search-ebscohost-com.ez.urosario.edu.co/login.aspx?direct=true&AuthType=ip&db=bth&AN=130640053&lang=es&site=eds-live&scope=site. Accessed on: june 14. 2022.

UN-HABITAT. **International guidelines on urban and territorial planning**, 2015. Available at: https://unhabitat.org/international-guidelines-on-urban-and-territorial-planning. Accessed on: june 14. 2022.

UNITED NATIONS. **Your Right to Build a Sustainable Future**: the Aarhus Convention, its Protocol on PRTRs and the Sustainable Convention, its Protocol on PRTRs and the Sustainable. Economic and Social Council, 2017. Available at: https://unece.org/fileadmin/DAM/env/pp/mop6/HLS/ECE_MP.PP_2017_18-_ECE_MP.PRTR_2017_4_E.pdf. Accessed on: sept. 25. 2021.

UNITED NATIONS. **SDG Acceleration Actions**. Available at: https://sdgs.un.org/partnerships/action-networks/acceleration-actions, 2019. Accessed on: sept. 25. 2021.

UNITED NATIONS SUSTAINABLE DEVELOPMENT GROUP (UNSDG). **MAPS**: a common approach to the UNDG's policy support to the SDGs. An update on implementation. United Nations Sustainable Development Group, 2016. Available at: https://www.un.org/ecosoc/sites/www.un.org.ecosoc/files/files/en/qcpr/doco-summary-brief-on-maps-march2016.pdf. Accessed on: july 26. 23

VEIGA, J. **Desenvolvimento Sustentável**: o desafio do século XXI. Rio de Janeiro: Garamond, 2010.

VELÁSQUEZ LEAL, L**. Oportunidades para la implementación de prácticas de buena gobernanza y rendición de cuentas en el seguimiento y fiscalización de los Objetivos de Desarrollo Sostenible en América Latina**, 2016. Available at: https://www.eurosai.org/en/databases/products/Oportunidades-para-la-implementacion-de-practicas-de-buena-gobernanza-y-rendicion-de-cuentas-en-el-seguimiento-y-fiscalizacion-de-los-Objetivos-de-Desarrollo-Sostenible-en-America-Latina/. Accessed on: june 14. 2022.

WORD RESOURCES INSTITUTE. **Collective Actions on Climate and Sustainable Development through the Open Government Partnership**. Open Government Partnership, 2018. Available at: https://www.opengovpartnership.org/wp-content/uploads/2017/10/Climate-Issue-Brief.pdf. Accessed on: june 14. 2022.

A framework proposal: analysing studies of circular economy with the institutional theory

Proposta de framework: analisando estudos de economia circular com a teoria institucional

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ABSTRACT

This study proposes a framework to facilitate the Circular Economy (CE) implementation cases analysis from the Institutional Theory (IT) perspective. The development of this theoretical framework was based on the levels of operationalisation of the Circular Economy and the types of isomorphic changes. To demonstrate the framework's applicability, we present a matrix classifying 59 case studies into nine quadrants (3 x 3). Subsequently, the papers' contents were discussed, revealing strategies and practices for institutional behavioural change that drive CE implementation at the micro, meso, and macro levels. Therefore, the results of this work contribute not only to academia by introducing a new way of analysing CE case studies but also to managers by discussing implemented or ongoing implementation cases.

Keywords: Circular economy. General packaging. Institutional theory. Isomorphism.

RESUMO

A presente pesquisa teve por objetivo propor um framework para propiciar a análise de casos de implantação da Economia Circular (EC) sob a perspectiva da Teoria Institucional (TI). A elaboração desta estrutura teórica teve por base os níveis de operacionalização da Economia Circular e os tipos de mudanças isomórficas. Para demonstrar a aplicabilidade do framework, foi apresentada uma matriz que classifica 59 (cinquenta e nove) estudos de caso, em 9 quadrantes (3 x 3). Em seguida, os conteúdos

dos papers foram discutidos, revelando estratégias e práticas para a mudança de comportamento institucional que alavanca rumo à implantação da EC, no nível micro, meso e macro. Portanto, os resultados deste trabalho contribuem não somente para a academia, ao introduzir uma nova forma de analisar estudos de caso de EC, como também para gestores, ao discutir casos implantados ou em fase de implantação.

Palavras-chave: Economia Circular. Embalagens em geral. Teoria Institucional. Isomorfismo.

1 INTRODUCTION

Unregulated markets, failed investments, and supply risks have led entire countries into increasingly prolonged economic recessions. Additionally, the primitive consumerist mindset prevails, posing a challenge to reduce the negative impacts of human activities on Earth (GEISSDOERFER *et al*., 2017).

The Covid-19 pandemic has generated an unprecedented crisis and brought negative economic consequences to various manufacturing and service sectors (MALISZEWSKA *et al*., 2020). Authors like Everingham and Chassagne (2020) criticise the myth of perpetual growth in capitalism and see the post-pandemic period as an opportunity to rethink the current economic model.

Regarding the high standard of production and consumption of goods, Ghisellini *et al*. (2016), for example, emphasise the urgency of changing business models to use fewer raw materials and energy and extend the lifespan of products. In this sense, Circular Economy (CE) emerges as an alternative. It aims to replace the linear take-make-dispose philosophy with a circular logic where actions of reduction, reuse, and recycling are implemented.

The pursuit of process efficiency to achieve product circularity is also present in other circular thought theories, such as biomimicry, regenerative design, and cradle-to-cradle (C2C) (EMF, 2013). However, the approach of CE is relatively new and lacks a deep theoretical foundation (KORHONEN *et al*., 2018).

Organisations compete not only for resources and customers but also for the power to influence policies and establish institutional legitimacy. Therefore, organisations must often change to adapt (DIMAGGIO; POWELL, 1983). In this context, Institutional Theory (IT) helps understand the macro environments of organisations. IT can facilitate stakeholder collaboration (SUDDABY, 2010), which is crucial for the viability of the circular supply chain and economic development (NORTH, 1991).

Thus, this study aims to apply Institutional Theory (IT) to analyse the operationalisation of the Circular Economy in the packaging chain. After this brief contextualisation and presentation of the main objective, we organised this paper as follows: the theoretical framework presents concepts of Circular Economy and the understanding of classical and contemporary authors about Institutional Theory.

Next, the methods section demonstrates the steps taken and the methodological classifications. Subsequently, this paper presents the framework created to analyse the implementation of CE from the perspective of Institutional Theory, and the same theoretical structure is applied to demonstrate its usefulness. Accordingly, the results are presented in matrix format and discussed, exposing the content of the analysed papers. Finally, the conclusion synthesises the paper's main contributions, acknowledges limitations, and suggests future research.

2 THEORETICAL BACKGROUND

2.1 CIRCULAR ECONOMY OF PACKAGING

The main purpose of the Circular Economy (CE) is linked to economic prosperity with environmental quality and equity (KIRCHHERR *et al*., 2017). The Ellen MacArthur Foundation (EMF) has extensively collaborated to promote the term CE through its participation in various editions of the World Economic Forum (EMF, 2013). CE proposes to reject the concept of waste, as it believes that materials still hold value even after their initial use, whether products have technical or biological cycles (GHISELLINI *et al*., 2016).

In order to describe the three main scales of CE operationalisation, Ghisellini *et al*. (2016) categorise and several subsequent works have used this pedagogical division (BRESSANELLI *et al*., 2021; LÜDEKE-FREUND *et al*., 2019). CE operationalisation is studied in products, companies, or consumers at the micro level. At the meso level, it is studied in a sector or eco-industrial parks, and at the macrolevel, it is evaluated in a city, region, or even between countries (GHISELLINI *et al*., 2016).

Among other studies that have also used this classification in their research, it is worth mentioning Lüdeke-Freund *et al*. (2019). From the literature, they presented 26 business models adopted in the circular economy and discussed their implementation strategies. Another study using this classification of CE operational levels was conducted by Oliveira, Luna, and Campos (2019). The authors examined the challenges of implementing the circular economy by analysing reverse channels and the supply chain of polystyrene packaging in Brazil (OLIVEIRA *et al*., 2019).

Marrucci (2020) warns that despite the growing interest of the scientific community in the subject, the volume of Municipal Solid Waste (MSW) has been increasing worldwide. Furthermore, the author states that the three levels of CE operationalisation have been analysed separately (MARRUCCI, 2020). Jacobi *et al*. (2018) affirm that it is more common to find works dedicated to the micro and meso levels, and there is still a lack of frameworks that aim to integrate the three levels.

At the macro level of analysis, many studies focus on municipal solid waste management (MARRUCCI, 2020). For example, Ferronato *et al*. (2019) investigate two recycling systems in developing countries and find that the complexity of CE practices increases as the scale level increases. To integrate the different operational levels (micro, meso, and macro), the authors emphasise the need for more assertive government policies of incentives and charges, the inclusion of the informal sector that contributes in a marginalised manner, public-private partnerships, and population awareness programs, among other measures (FERRONATO *et al*., 2019).

Figure 1 illustrates the segmentation researchers use to observe the transition to CE. As this is a theoretical division, it is reiterated that circular practices involving phases such as planning, procurement, design, and production need to be integrated for the preservation of ecosystems and the well-being of society (MURRAY *et al*., 2015).

Figure 1 | Levels of analysis of the operationalisation of the Circular Economy

Source: Adapted from Murray et al. (2015).

General packaging consists of materials such as paper, plastic, metal, or glass designed, created, and used to protect and facilitate product transportation, storage, and commercialisation. For example, packaging for food and beverages provides protection and safety for these products during transportation and storage (BATISTA *et al*., 2018; LASO *et al*., 2016). However, it is essential to remember that packaging, in general, is a significant contributor to urban solid waste (BOESEN *et al*., 2019; EMF, 2013).

Specifically regarding packaging, European countries are pioneers in seeking sustainable development through a paradigm shift: transitioning from a linear economy to a circular economy (RUBIO *et al*., 2019). The European Union, an economic bloc of countries, aims to embrace the concept of circularity in sustainable production, focusing on avoiding waste generation and promoting activities that extend the lifespan of products, such as reuse and recycling (LASO *et al*., 2016).

2.2 INSTITUTIONAL THEORY

In order to understand the ideas and behaviour patterns of institutions, as well as the values and beliefs of individuals that impact and are impacted by them, North (1994) proposes the theory of institutional analysis. According to North (1994), institutions play a fundamental role in economic growth. They provide confidence in determining outcomes, limit individual choices, and change over time, altering the available options. Institutions, such as customs and rules, affect individuals' incentives and disincentives, influencing the array of available economic choices.

To achieve economic growth through productivity, it is essential to understand institutions and how they shape the economy, as North's institutional analysis theory (1994) suggests. Thus, Institutional Theory (IT) can contribute to the maturation of debates towards the operationalisation of the Circular Economy. Understanding organisations is fundamental for order and progress, as they form the basis of social life. By comprehending them, one expands the understanding of the meaning people give to life and moves towards societal stability (CAMPBELL, 2004). There is a continuous conflict of interests in the organisational field, motivating institutions to make changes, seek adaptation, or even survive in the environment (DACIN *et al*., 2002). Organisational changes can happen radically or incrementally, and often, it is difficult to perceive that changes are underway (CAMPBELL, 2004).

During the 1980s, Institutional Theory developed in response to the challenge of understanding the increasingly intense and frequent changes happening (and continuing to happen) worldwide (SCOTT, 1991). The same author attributes the most outstanding contribution of institutional theorists to the

re-conceptualisation of organisational environments (SCOTT, 1991). Environments could be divided into technical and institutional, with the former involving information exchange and complex technology, while the institutional environment involves formal and informal rules, socially defined categories (MEYER; ROWAN, 1977; SCOTT, 1991).

Being part of an institutionalised environment is a characteristic of organisations in modern society, as these institutions are composed of professionals directed by policies and programs aimed at rationality and efficiency in resource use. Organisations need to grow in legitimacy to increase their survival chances (MEYER; ROWAN, 1977), and these structured fields tend to lead organisations to adopt similar behaviour. Isomorphism, therefore, emerges as a concept that translates this impetus of organisational units seeking similar attitudes as they face similar problems (DIMAGGIO; POWELL, 1983).

Besides overcoming market challenges, organisations need to interact with other organisations constantly. They compete for resources, customers, and power to influence policies and establish institutional legitimacy, so they must continuously change to adapt. Thus, isomorphism becomes vital in understanding what makes companies similar (DIMAGGIO; POWELL, 1983).

Dimaggio and Powell (1983) list three mechanisms to differentiate institutional isomorphic changes, namely: 1) coercive isomorphism, which derives from political influences, for example, when the state induces or forces organisations to adopt measures or change behaviours; 2) mimetic isomorphism, a tendency towards homogenisation arising from standardised responses to uncertainty, often occurring when organisations copy other successful ones; and 3) normative isomorphism, which usually arises from professionalisation projects, motivated to respect obligations that arise and are demanded by society. It is worth noting that the types are not pure, meaning they are not exclusive but rather interactive.

Suddaby (2010) believes in theories' importance in fostering more productive organisational changes; he states that theories are tools. In this author's opinion, the institutional theory is helpful for this macro understanding of organisational environments, and this paradigm can even lead to ease of collaboration among stakeholders and consequently facilitate access to resources.

Institutions, therefore, arise from political, economic, and social interaction. Thus, institutionalisation is the process of making institutions widely known and perpetuating them in the long term. The frameworks that support institutionalisation can potentially contribute to economic growth as they reduce costs and increase cooperation among economic agents (NORTH, 1991).

3 METHODOLOGICAL PROCEDURES

In order to propose a framework to facilitate the analysis of Circular Economy (CE) implementation cases, it is essential to highlight the significance of creating these theoretical structures. A framework is a tool to aid in understanding complexities in the real world. Therefore, they are researchers' creations for comprehending phenomena that still lack analysis. The development of these models contributes to clarifying the relationship between elements, including possible cause-effect relationships (MUNCK *et al*., 2013).

According to Shehabuddeen, Probert, and Phaal (2000), frameworks can take different forms: simple, elaborate, descriptive, or causal. Theoretical structures differ from simple mappings as they represent abstractions of dynamic, non-static events.

Furthermore, Shehabuddeen, Probert, and Phaal (2000) state that developing a theoretical structure involves identifying specific purposes. Subsequently, a structure of relationships is created by establishing categories. Hence, three questions were formulated to guide the bibliographic classification: 1) Which levels of operation of the Circular Economy for packaging are most studied? 2) Which mechanisms of institutional change towards the Circular Economy for packaging are most studied? 3) What are the existing trends and research gaps?

Figure 2 illustrates the framework created by the authors of this study.

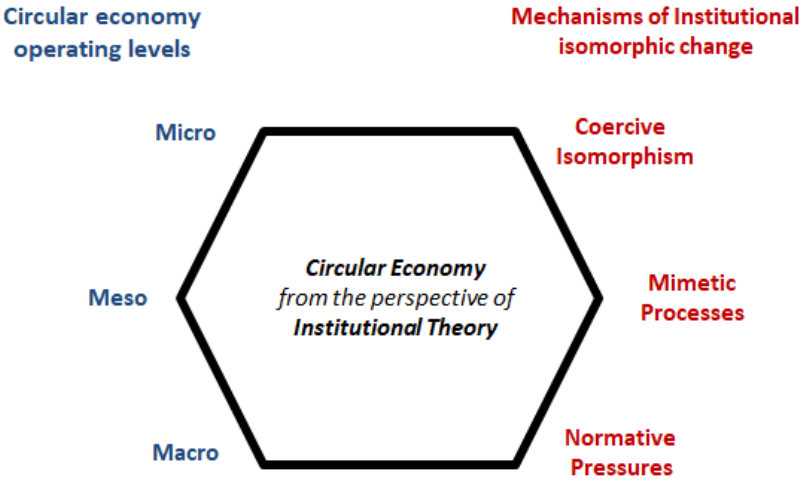

Figure 2 | Framework for analysing the CE from the perspective of IT

Source: Authors.

Figure 2 relates a well-established administrative theory (Institutional Theory) with an emerging and increasingly used theory in the fields of engineering, management, and applied social and environmental sciences (Circular Economy). This created structure allows analysts to reflect and investigate the levels of operation of CE and the mechanisms of institutional change that could contribute to the institutionalisation of practices that promote sustainable development.

The next section, dedicated to presenting and discussing the results, used the Integrative Literature Review conducted by Cerqueira-Streit *et al*. (2022) to apply the developed framework. This review incorporated theoretical and empirical articles, seminal and more recent articles published in international journals on the Circular Economy of packaging.

It is important to emphasise that the content analysis was of the thematic categorical type, according to Bardin (2011). In other words, a text fragment can give rise to a category of analysis. If this excerpt is homogeneous, exhaustive, and pertinent, a specific communication segment can be considered a category of analysis.

Although the three isomorphism types are often mixed in practice, Dimaggio and Powell (1983) reinforce that the theoretical division can facilitate the analysis of different pressures. Therefore, the authors of this research analysed all 59 case studies that are part of the sample of the Integrative Literature Review conducted by Cerqueira-Streit *et al*. (2022). This RIL is aligned with the interests of this research; the search criteria were systematic, allowing the following classification: 1) regarding the level of operationalisation of CE for Packaging (micro, meso, and macro) and 2) regarding the mechanisms for institutional change towards CE for Packaging (coercive, mimetic, or normative isomorphism).

4 RESULTS AND DISCUSSION

The understanding of this study about CE aligns with studies that represent CE as a paradigm shift. This change aims to promote waste generation prevention, energy and material savings by closing the production cycle, and it is believed that it can be implemented at the micro, meso, or macro levels. At the micro level, companies and consumers are studied, while at the meso level, changes in economic agents participating in the same sector are analysed from a symbiotic perspective. At the macro level, cities, regions, or countries are studied to compare general governmental, business, and societal attitudes.

It is essential to mention that the articles were classified according to the locus where the studies were applied (micro, meso, or macro) and the authors' mention of possible isomorphic behaviours (coercive, mimetic, or normative). For example, Kuo *et al*. (2019) was classified in the present structure as Micro and Coercive. The researchers interviewed managers from a single LCD (Liquid Crystal Display) panel manufacturing plant to investigate the possibility of changing to a less degrading logistics system with higher quality and more reusable packaging.

Throughout the work, the researchers emphasise the importance of regulation to force companies to restructure logistics and modus operandi regarding work safety, efficiency, storage activities, and product handling. Regulation can even alter how companies communicate and instruct customers about proper consumption, handling, and disposal (KUO *et al*., 2019).

By conducting five expert interviews and eight non-participant observations in a hospital in Antwerp (Belgium), Harding *et al*. (2021) made important considerations about packaging waste management in the hospital environment. They reflected on the quantity and quality of various types of packaging generated, such as plastic, paper, metal, and multilayer packaging (which combine more than one material). They also discussed the importance of sterilisation centres and the use of packaging for protection after sterilisation. The authors emphasised the need to "ecologise" hospitals, including surgical rooms, to reduce waste and optimise reuse processes (through sterilisation) and recycling when possible. In the authors' view, this hospital is ahead of others in seeking such actions and is now an example to be followed. The presence of successful circular practices and the encouragement of benchmarking characterise the stimulus for mimetic isomorphism (HARDING *et al*., 2021).

Understanding consumer behaviour can be considered a stimulus for investigations at the micro level of CE operation, as the success of this new paradigm also depends on individual practices. Abuabara *et al*. (2021) interviewed 40 participants from the coffee capsule supply chain (plastic and aluminium packaging) to understand consumers' interests in aspects related to reverse logistics and environmental management. As a primary output, the authors developed a theoretical framework to assist managers in decision-making based on the thoughts and actions of end consumers.

Community engagement tends to bring positive collective impacts on the environment and well-being. When these actors push for more professional projects from companies that implement serious reverse logistics programs or demonstrate concern for waste management, the importance of normative mechanisms in institutionalising CE becomes evident. It is necessary to stimulate conscious behaviour and civil responsibility so consumers more frequently opt for "eco-friendly" products and companies, valuing those that act appropriately and creating competition for more sustainable actions (ABUABARA *et al*., 2019).

Table 1 presents the matrix in which the 59 case studies on CE of packaging were classified, demonstrating the application of the proposed framework.

Table 1 | Case studies in the Circular Economy of packaging analysed according to Institutional

		Mechanism of isomorphic institutional change		
		Coercive Isomorphism	**Mimetic proccess**	**Normative proccess**
Levels of operationalisation of the Circular Economy	Micro	Ameli *et al*. (2019); Guerin (2020b); Kuo *et al*. (2019); Laso *et al*. (2018).	Guerin (2020a); Harding *et al*. (2021); Leissner; Ryan-Fogarty (2019); Marrucci *et al.* (2020); Principato *et al*. (2019); Selina *et al*. (2021).	Abuabara *et al*. (2019); Ermolaeva; Rybakova (2019); Jang *et al*. (2020); Marotta *et al.* (2019); Rizzo *et al.* (2017); Stephan *et al*. (2020); Virsta *et al*. (2020).
	Meso	Bruno *et al*. (2020); Kazulyte; Kruopiene (2018); Laso *et al*. (2016).	Bishop *et al*. (2021); Friedrich *et al.* (2020); Niero *et al*. (2017); Usapein; Chavalparit (2014).	Casarejos *et al*. (2018); Husgafvel *et al.* (2018); Mura *et al.* (2020).
	Macro	Andreasi Bassi *et al*. (2020); Bogusz *et al*. (2021); Ezeudu; Ezeudu (2019); Foschi *et al*. (2021); Fuss *et al*. (2021); Guarnieri *et al*. (2020); Kranzinger *et al*. (2017); Kudela *et al.* (2020); Polygalov *et al*. (2021); Rigamonti *et al*. (2019); Roithner; Rechberger (2020); Rubio *et al*. (2019); Rutkowski (2020); Thabit *et al*. (2020).	Aznar-Sánchez *et al*. (2020); Faussone (2018); Fitch-Roy *et al*. (2021); Jeswani *et al*. (2021); Nevrlý *et al*. (2021); Nimmegeers; Billen (2021); Oyelola *et al*. (2017); Pluskal *et al*. (2021); Somplák *et al*. (2019); Van Eygen *et al*. (2018)	Allison *et al*. (2021); Lucia; Pazienza (2019); Jang *et al*. (2020); Kakadellis *et al*. (2021); Miliute-Plepiene; Plepys (2015); Roche Cerasi *et al.* (2021); Simoens; Leipold (2021); Taffuri *et al*. (2021).

Source: Research data.

After discussing some articles that addressed the micro level with different mechanisms of isomorphic change and presenting Table 1, the following paragraphs highlight the studies that addressed the meso and macro levels.

In addressing the fish industry chain, Laso *et al*. (2016) used Life Cycle Assessment (LCA) to identify the best treatment for the waste of canned anchovy: the head, bones, scales, and unutilised meat. The LCA is a quantitative tool inspired by eco-efficiency principles, allowing the reduction of the environmental footprint by controlling the product's utility.

The unused parts of the fish (head and bones) can produce fishmeal and fish oil. The authors also state that fish scales and skin can be valorised in producing bioplastics for packaging, as technology is already available for such utilisation (LASO *et al*., 2016).

Considering the substitution of single-use packaging, which would be discarded after the first use, is part of the search for solutions proposed by the Circular Economy (EC). Disposal in landfills or incineration was considered the least advantageous due to the high government costs. At this point, the work fits as coercive since the authors indicate that the sector's pursuit of eliminating the concept of waste is motivated by the attempt to comply with European environmental legislation (LASO *et al*., 2016).

One of the studies classified as meso (as it is applied in a specific industrial sector), with the isomorphic mechanism considered mimetic, was Niero *et al*. (2017). In this study, the authors present a framework combining Life Cycle Assessment with Cradle to Cradle (C2C) certification for aluminium cans in the Carlsberg brewery industry. It becomes more evident that adjustments like this are motivated by the fact that the studied company does not want to fall behind the competition, characterising mimetic isomorphism.

By achieving certification like C2C, companies progress toward EC and can prove it to the entire market, helping them gain a competitive advantage. One of the main challenges in implementing EC strategies is product design, meaning that the product is designed and built from the beginning to facilitate reuse, reconditioning, and other R's (NIERO *et al*., 2017).

In stating the importance of C2C certification, the authors mention several times the pioneering nature of the beverage industry and how various others are seeking adaptation (not just Carlsberg and its chain). Indeed, understanding what the authors call the "Carlsberg community" facilitates understanding the meso level that aims to move toward EC (NIERO *et al*., 2017).

In addition to solid legislation and incentives for industry compliance, customer demand is essential. Husgafvel *et al*. (2018) investigated the opportunities and challenges of wood reuse by applying questionnaires and conducting semi-structured interviews with large and small companies. In addition to the furniture and carpentry industry, wood is a material that can be used in sawmills, pallet construction, and packaging manufacturing.

This study was classified as normative, as the authors emphasise the importance of society in demanding that companies increase their level of professionalism and consider sustainability issues. In Finland, where this case was studied, public opinion is believed to play a fundamental role in companies' view of corporate responsibility as an opportunity to add value to their businesses (HUSGAFVEL *et al*., 2018).

By analysing the implementation of the first phase of the Sectoral Agreement for packaging in Brazil, Guarnieri *et al*. (2020) used documentary analysis and semi-structured interviews with government representatives, companies, and recyclable material pickers. Although the term CE is not present in the Brazilian National Solid Waste Law (No. 12,305/10), its objectives, principles, and instruments are believed to align with what this new paradigm advocates (BRASIL, 2010).

In its first phase, the sectoral agreement showed interesting results regarding support for picker cooperatives (who collect, sort, and facilitate the shipment of packaging for recycling), installation of PEVs (Voluntary Delivery Points), and environmental education programs for the population. However, the authors point out that this phase happened as a pilot project since it was implemented only in 12 Brazilian cities, those that would host the World Cup in 2014 and, therefore, had more significant logistical infrastructure (GUARNIERI *et al*., 2020).

The authors defend coercive isomorphism as they believe the law should be implemented throughout the Brazilian territory, respecting the principles of shared responsibility and socio-productive inclusion of the pickers (GUARNIERI *et al*., 2020).

The industry and consumers have appreciated the incredible versatility of plastic for decades. The composition of these polymers has significantly contributed to food packaging, especially the use of multilayer plastics, which help prevent food from coming into contact with light, moisture, or oxygen. However, according to Nimmegeers and Billen (2021), these properties make plastic a versatile material, leading to increased complexity in the recycling chain.

Through statistical analyses conducted by the authors, this study investigated the wide range of plastic packaging waste in Belgium. Issues related to the complexities in the collection (due to widespread use) and recyclability (due to multilayers) were discussed, and the authors presented the waste flows that contribute most to the complexity of separation. Therefore, the authors recommend that this statistical model be applied to other case studies, characterising the idea of imitation and applying best practices typical of the mimetic isomorphism mechanism (NIMMEGEERS; BILLEN, 2021).

Finally, it is worth highlighting at least one work included among those that addressed the macro level of circular economy and advocated normative isomorphism for its institutionalisation. Despite Extended Producer Responsibility (EPR) in German legislation since the 1990s, Simoens and Leipold (2021) claim that many obstacles remain to its operation.

Similarly to Brazil, the packaging sector in Germany has various coalitions that vehemently defend their interests. These groups include legislators, producers, distributors, and well-established waste management companies (SIMOENS; LEIPOLD, 2021).

In Germany, the packaging sector can also be divided between those who advocate privatisation and those who support greater municipal control over waste management. Among the main challenges reported, the authors state that German consumers still exhibit low behaviour towards selective waste collection, and more awareness-raising actions are needed. The results of this paper indicate that the real transition to the Circular Economy will happen gradually and necessarily involves increasing citizens' demand for more efficient collection and recycling systems, whether operated by the government or companies (SIMOENS; LEIPOLD, 2021).

5 CONCLUDING REMARKS

The current economic model shows few signs of sustainability. Finite natural resources are increasingly scarce, social ills such as hunger and lack of basic sanitation persist, and economic problems like unemployment and class inequalities continue to grow. Therefore, there is an urgent need for a paradigm shift to replace the current model of production and consumption with a less degrading and, consequently, more sustainable approach.

Enter the Circular Economy as a new way of doing business, which emphasises minimising the use of raw materials and energy and extending the utility of products and their components. Therefore, this paper's central objective was to develop a framework capable of analysing the operationalisation of the Circular Economy in the packaging chain based on already published empirical cases and from the perspective of Institutional Theory.

The results of this research can be summarised in Figure 2 and Table 1. Figure 2 highlights the framework created for the analysis of the Circular Economy from the perspective of Institutional Theory, while Table 1 demonstrates its application. With this goal in mind, a matrix was created with the 59 case studies on the Circular Economy of packaging, which were analysed from the perspective of Institutional Theory (Table 1).

The content of some of these articles was discussed to demonstrate their classification and to present tools such as Life Cycle Assessment (LCA), Cradle-to-Cradle (C2C) certification, and Extended Producer Responsibility (EPR). It is worth noting that the criterion adopted was presenting at least one article from each quadrant. Therefore, 9 (nine) articles resulting from the 3 x 3 (three times three) cross-cutting of the 6 (six) thematic categories were discussed (micro, meso, macro, coercive isomorphism, mimetic, and normative).

Despite numerous case studies at various levels of analysis and indicated isomorphic change, the topic is far from being exhausted. This work highlights the variety of places, methods, scopes, and different materials that research on the Circular Economy of packaging can cover.

This study's main limitation is its reliance on arguments based on analysts' interpretations, which facilitated the classification of the articles. Despite this limitation, the article stimulates reflections on the practice of the Circular Economy of Packaging in light of Institutional Theory. During the discussion

of the cases, it demonstrates the application of strategies and tools that lead to the 3Rs (reduction, reuse, and recycling) and debates their results. This article's main theoretical contribution is to create a structure capable of analysing real cases of the Circular Economy. In addition, this work proved helpful in filling the gap raised by Korhonen *et al*. (2018). These authors warned that studying the Circular Economy in the light of a theory would be a rich contribution to the field. Additionally, authors like Fischer and Pascucci (2017) indicated the need for the Circular Economy to be studied based on well-established scientific theories, as with Institutional Theory.

Future studies can apply the framework presented to evaluate other Circular Economy works, not limited to those dealing with recyclable materials. We also hope that new studies based on other administrative theories will be written and published, thus perhaps giving the Circular Economy the necessary robustness to continue growing in academia and public and private organisations.

REFERENCES

ABUABARA, L.; PAUCAR-CACERES, A.; BURROWES-CROMWELL, T. Consumers' values and behaviour in the Brazilian coffee-in-capsules market: promoting circular economy. **International Journal of Production Research**, v. 57, n. 23, p. 7269–7288, 2019. Available at: https://doi.org/10.1080/00207543.2019.1629664

ALLISON, A. L. *et al*. Barriers and enablers to buying biodegradable and compostable plastic packaging. **Sustainability** (Switzerland), v. 13, n. 3, p. 1–15, 2021. Available at: https://doi.org/10.3390/su13031463

AMELI, M.; MANSOUR, S.; AHMADI-JAVID, A. A simulation-optimization model for sustainable product design and efficient end-of-life management based on individual producer responsibility. **Resources, Conservation and Recycling**, v. 140, n. 1, p. 246–258, 2019. Available at: https://doi.org/10.1016/j.resconrec.2018.02.031

ANDREASI BASSI, S. *et al*. Extended producer responsibility: How to unlock the environmental and economic potential of plastic packaging waste? **Resources, Conservation and Recycling**, v. 162, n. 1, 105030, 2020. Available at: https://doi.org/10.1016/j.resconrec.2020.105030

AZNAR-SÁNCHEZ, J. A. *et al*. Identification of opportunities for applying the circular economy to intensive agriculture in Almería (South-East Spain). **Agronomy**, v. 10, n. 10, 2020. Available at: https://doi.org/10.3390/agronomy10101499

BARDIN, L. **Análise de Conteúdo**. Edições 70, 2011.

BATISTA, L. *et al*. In search of a circular supply chain archetype – a content-analysis-based literature review. **Production Planning and Control**, v. 29, n. 6, p. 438–451, 2018. Available at: https://doi.org/10.1080/09537287.2017.1343502

BOESEN, S.; BEY, N.; NIERO, M. Environmental sustainability of liquid food packaging: Is there a gap between Danish consumers' perception and learnings from life cycle assessment? **Journal of Cleaner Production**, v. 210, p. 1193–1206, 2019. Available at: https://doi.org/10.1016/j.jclepro.2018.11.055

BOGUSZ, M. *et al*. The concept of zero waste in the context of supporting environmental protection by consumers. **Energies**, v. 14, n. 18, 2021. Available at: https://doi.org/10.3390/en14185964

BRASIL. **Lei n. 12.305, de 2 de agosto de 2010**. Institui a Política Nacional de Resíduos Sólidos, 2010.

BRUNO, G. *et al*. Decarbonization of the Cement Industry – Production of Solid Fuel From Non-Hazardous Waste. **Procedia Environmental Science, Engineering and Management**, v. 7, n. 2, p. 277–286, 2020.

CAMPBELL, J. L. **Institutional Change and Globalization**. In Princeton: University Press, 2004.

CASAREJOS, F. *et al*. Rethinking packaging production and consumption vis-à-vis circular economy: a case study of compostable cassava starch-based material. **Journal of Cleaner Production**, v. 201, p. 1019–1028, 2018. Available at: https://doi.org/10.1016/j.jclepro.2018.08.114

CERQUEIRA-STREIT, J. A.; OLIVEIRA, L. **Contribuições da Gestão de Resíduos de Embalagens para a Economia Circular**: uma revisão integrativa da literatura. XXIII SIMPOI - SIMPÓSIO DE ADMINISTRAÇÃO DA PRODUÇÃO, LOGÍSTICA E OPERAÇÕES INTERNACIONAIS. São Paulo-SP, 2022.

DACIN, T.; GOODSTEIN, J.; SCOTT, R. Institutional Theory and Institutional change: introduction to special research forum. **Academy of Management Journal**, v. 45, n. 1, p. 45–57, 2002.

DIMAGGIO, P. J.; POWELL, W. W. The Iron Cage Revisited: institutional isomorphism and collective rationality in organizational fields. **American Sociological Review**, v. 48, n. 2, p. 147–160, 1983. Available at: https://doi.org/10.2307/2095101

EMF. Ellen MacArthur Foundation. Towards the Circular Economy Vol. 1: Economic and business rationale for an accelerated transition. **Ellen Macarthur Foundation**, v. 1, p.1–96, 2013. Available at: https://doi.org/10.1162/108819806775545321

EVERINGHAM, P.; CHASSAGNE, N. Post Covid-19 ecological and social reset: moving away from capitalist growth models towards tourism as Buen Vivir. **Tourism Geographies**, v. 1, p. 1–12, 2020. Available at: https://doi.org/10.1080/14616688.2020.1762119

EZEUDU, O. B.; EZEUDU, T. S. Implementation of circular economy principles in industrial solid waste management: case studies from a developing economy (Nigeria). **Recycling**, v. 4, n. 4, 2019. Available at: https://doi.org/10.3390/recycling4040042

FAUSSONE, G. C. Transportation fuel from plastic: two cases of study. **Waste Management**, v. 73, p. 416–423, 2018. Available at: https://doi.org/10.1016/j.wasman.2017.11.027

FERRONATO, N. *et al*. Introduction of the circular economy within developing regions: a comparative analysis of advantages and opportunities for waste valorization. **Journal of Environmental Management**, v. 230, n. 1, p. 366–378, 2019. Available at: https://doi.org/10.1016/j.jenvman.2018.09.095

FISCHER, A.; PASCUCCI, S. Institutional incentives in circular economy transition: the case of material use in the Dutch textile industry. **Journal of Cleaner Production**, v. 155, p. 17–32, 2017. Available at: https://doi.org/10.1016/j.jclepro.2016.12.038

FITCH-ROY, O.; BENSON, D.; MONCIARDINI, D. All around the world: assessing optimality in comparative circular economy policy packages. **Journal of Cleaner Production**, v. 286, 125493, 2021. Available at: https://doi.org/10.1016/j.jclepro.2020.125493

FOSCHI, E.; D'ADDATO, F.; BONOLI, A. Plastic waste management: a comprehensive analysis of the current status to set up an after-use plastic strategy in Emilia-Romagna Region (Italy). **Environmental Science and Pollution Research**, v. 28, n. 19, p. 24328–24341, 2021. Available at: https://doi.org/10.1007/s11356-020-08155-y

FRIEDRICH, K. *et al*. Benchmark analysis for plastic recyclates in Austrian waste management. **Detritus**, v. 9, p. 105–112, 2020. Available at: https://doi.org/10.31025/2611-4135/2019.13869

FUSS, M.; BARROS, R. T. V.; POGANIETZ, W. R. The role of a socio-integrated recycling system in implementing a circular economy – The case of Belo Horizonte, Brazil. **Waste Management**, v. 121, p. 215–225, 2021. Available at: https://doi.org/10.1016/j.wasman.2020.12.006

GEISSDOERFER, M. *et al*. Circular business models: a review. **Journal of Cleaner Production**, v. 277, 123741, 2020. Available at: https://doi.org/10.1016/j.jclepro.2020.123741

GHISELLINI, P.; CIALANI, C.; ULGIATI, S. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. **Journal of Cleaner Production**, v. 114, p. 11–32, 2016. Available at: https://doi.org/10.1016/j.jclepro.2015.09.007

GUARNIERI, P.; CERQUEIRA-STREIT, J.; BATISTA, L. Reverse logistics and the sectoral agreement of packaging industry in Brazil towards a transition to circular economy. **Resources, Conservation and Recycling**, v. 153, 104541, 2020. Available at: https://doi.org/10.1016/j.resconrec.2019.104541

GUERIN, T. F. Evaluating treatment pathways for managing packaging materials from construction of a solar photovoltaic power station. **Waste Management and Research**, v. 38, n. 12, p. 1345–1357, 2020. Available at: https://doi.org/10.1177/0734242X20939627

HARDING, C. *et al*. Design opportunities to reduce waste in operating rooms. **Sustainability** (Switzerland), v. 13, n. 4, p. 1–14, 2021. Available at: https://doi.org/10.3390/su13042207

HUSGAFVEL, R. *et al*. Forest sector circular economy development in Finland: a regional study on sustainability driven competitive advantage and an assessment of the potential for cascading recovered solid wood. **Journal of Cleaner Production**, v. 181, p. 483–497, 2018. Available at: https://doi.org/10.1016/j.jclepro.2017.12.176

JACOBI, N. *et al*. Providing an economy-wide monitoring framework for the circular economy in Austria: status quo and challenges. **Resources, Conservation and Recycling**, v. 137, p. 156–166, 2018. Available at: https://doi.org/10.1016/j.resconrec.2018.05.022

JANG, Y. C. *et al*. Recycling and management practices of plastic packaging waste towards a circular economy in South Korea. **Resources, Conservation and Recycling**, v. 158, 104798, 2020. Available at: https://doi.org/10.1016/j.resconrec.2020.104798

KAKADELLIS, S.; WOODS, J.; HARRIS, Z. M. Friend or foe: stakeholder attitudes towards biodegradable plastic packaging in food waste anaerobic digestion. **Resources, Conservation and Recycling**, v. 169, 2021. Available at: https://doi.org/10.1016/j.resconrec.2021.105529

KIRCHHERR, J.; REIKE, D.; HEKKERT, M. Conceptualizing the circular economy: an analysis of 114 definitions. **Resources, Conservation and Recycling**, v. 127, p. 221–232, 2017. Available at: https://doi.org/10.1016/j.resconrec.2017.09.005

KORHONEN, J.; HONKASALO, A.; SEPPÄLÄ, J. Circular Economy: the concept and its limitations. **Ecological Economics**, v. 143, p. 37–46, 2018. Available at: https://doi.org/10.1016/j.ecolecon.2017.06.041

KUO, T. C. *et al*. The circular economy of LCD panel shipping in a packaging logistics system. Resources, Conservation and Recycling, v. 149, p. 435–444, 2019. Available at: https://doi.org/10.1016/j.resconrec.2019.06.022

LASO, J. *et al*. Waste management under a life cycle approach as a tool for a circular economy in the canned anchovy industry. **Waste Management and Research**, v. 34, n. 8, p. 724–733, 2016. Available at: https://doi.org/10.1177/0734242X16652957

LASO, J. *et al*. Introducing the Green Protein Footprint method as an understandable measure of the environmental cost of anchovy consumption. **Science of the Total Environment**, v. 621, p. 40–53, 2018. Available at: https://doi.org/10.1016/j.scitotenv.2017.11.148

LUCIA, C.; PAZIENZA, P. Market-based tools for a plastic waste reduction policy in agriculture: a case study in the south of Italy. **Journal of Environmental Management**, v. 250, n. 1, 109468, 2019. Available at: https://doi.org/10.1016/j.jenvman.2019.109468

LÜDEKE-FREUND, F.; GOLD, S.; BOCKEN, N. A Review and Typology of Circular Economy Business Model Patterns. **Journal of Industrial Ecology**, v. 23, n. 1, p. 36–61, 2019. Available at: https://doi.org/10.1111/jiec.12763

MALISZEWSKA, M.; MATTOO, A.; MENSBRGGHE, D. The Potential Impact of Covid-19 on GDP and Trade A Preliminary Assessment. **Policy Research Working Paper**, v. 9211, p. 1–24, 2020.

MAROTTA, D. *et al*. Disposal and reuse in the circular economy: reduction of plastic materials in products of large-scale distribution. **Procedia Environmental Science, Engineering and Management**, v. 6, n. 1, p. 103–109, 2019.

MARRUCCI, L.; MARCHI, M.; DADDI, T. Improving the carbon footprint of food and packaging waste management in a supermarket of the Italian retail sector. **Waste Management**, v. 105, p. 594–603, 2020. Available at: https://doi.org/10.1016/j.wasman.2020.03.002

MILIUTE-PLEPIENE, J.; PLEPYS, A. Does food sorting prevents and improves sorting of household waste? A case in Sweden. **Journal of Cleaner Production**, v. 101, p.182–192, 2015. Available at: https://doi.org/10.1016/j.jclepro.2015.04.013

MUNCK, L. *et al*. Em busca da sustentabilidade organizacional: a proposição de um framework. **Revista Alcance**, v. 20, n. 4, p. 460-477, 2013.

MURRAY, A.; SKENE, K.; HAYNES, K. The Circular Economy: an interdisciplinary exploration of the concept and application in a global context. **Journal of Business Ethics**, v. 140, n. 3, p. 369-380, 2017.

NIERO, M. *et al*. Combining Eco-Efficiency and Eco-Effectiveness for Continuous Loop Beverage Packaging Systems: lessons from the Carlsberg Circular Community. **Journal of Industrial Ecology**, v. 21, n. 3, p. 742–753, 2017. Available at: https://doi.org/10.1111/jiec.12554

NIMMEGEERS, P.; BILLEN, P. Quantifying the Separation Complexity of Mixed Plastic Waste Streams with Statistical Entropy: a plastic packaging waste case study in Belgium. **ACS Sustainable Chemistry and Engineering**, v. 9, n. 29, p. 9813–310, 2021. Available at: https://doi.org/10.1021/acssuschemeng.1c02404

NORTH, D. C. Institutions. **Journal of Economic Perspectives**, v. 5, n. 1, p. 97-112, 1991.

NORTH, D. C. **La nueva economía institucional y el desarrollo**. Fundes, 1994.

OLIVEIRA, C. T.; LUNA, M.; CAMPOS, L. Understanding the Brazilian expanded polystyrene supply chain and its reverse logistics towards circular economy. **Journal of Cleaner Production**, v. 235, p. 562–573, 2019. Available at: https://doi.org/10.1016/j.jclepro.2019.06.319

OYELOLA, O.; AJIBOSHIN, I.; OKEWOLE, J. Effective solid waste management in the circular economy: the case study of Lagos State, Nigeria. **Procedia Environmental Science, Engineering and Management**, v. 4, n. 3, p. 143–148, 2017.

PLUSKAL, J. *et al*. Strategic decisions leading to sustainable waste management: separation, sorting and recycling possibilities. **Journal of Cleaner Production**, v. 278, 2021. Available at: https://doi.org/10.1016/j.jclepro.2020.123359

POLYGALOV, S. *et al*. Determination of the composition and properties of PET bottles: evidence of the empirical approach from Perm, Russia. **Waste Management and Research**, v. 39, n. 5, p. 720–730, 2021. Available at: https://doi.org/10.1177/0734242X211011222

PRINCIPATO, L. *et al*. Adopting the circular economy approach on food loss and waste: the case of Italian pasta production. **Resources, Conservation and Recycling**, v. 144, p. 82–89, 2019. Available at: https://doi.org/10.1016/j.resconrec.2019.01.025

ROCHE CERASI, I. *et al*. Household plastic waste habits and attitudes: a pilot study in the city of Valencia. **Waste Management and Research**, v. 39, n. 5, p. 679–689, 2021. Available at: https://doi.org/10.1177/0734242X21996415

ROITHNER, C.; RECHBERGER, H. Implementing the dimension of quality into the conventional quantitative definition of recycling rates. **Waste Management**, v. 105, p. 586–593, 2020. Available at: https://doi.org/10.1016/j.wasman.2020.02.034

RUBIO, S. *et al*. Effectiveness of extended producer responsibility policies implementation: the case of Portuguese and Spanish packaging waste systems. **Journal of Cleaner Production**, v. 210, p. 217–230, 2019. Available at: https://doi.org/10.1016/j.jclepro.2018.10.299

RUTKOWSKI, J. E. Inclusive packaging recycling systems: improving sustainable waste management for a circular economy. **Detritus**, v. 13, n. 314, p. 29–46. 2020. Available at: https://doi.org/10.31025/2611-4135/2020.14037

SCOTT, W. R. Unpacking institutional arguments. In: POWELL, W. W.; DIMAGGIO, P. J. **The new institucionalism in organizational analysis**, p. 164–182, 1991.

SELINA, M. *et al*. Wet-mechanical processing of a plastic-rich two-dimensional-fraction from mixed wastes for chemical recycling. **Waste Management and Research**, v. 39, n. 5, p. 731–743. Available at: https://doi.org/10.1177/0734242X21996435

SHEHABUDDEEN, N. *et al*. **Management Representations and Approaches**: exploring issues surrounding frameworks. Working Paper for BAM, Cambridge, 2000.

SIMOENS, M. C.; LEIPOLD, S. Trading radical for incremental change: the politics of a circular economy transition in the German packaging sector. **Journal of Environmental Policy and Planning**, v. 23, n. 6, p. 822–836, 2021. Available at: https://doi.org/10.1080/1523908X.2021.1931063

SOMPLÁK, R. *et al*. Implementation of circular economy through the mathematical programming for the complex system evaluation. **Chemical Engineering Transactions**, v. 76, p. 523–528, 2019. Available at: https://doi.org/10.3303/CET1976088

SUDDABY, R. Challenges for institutional theory. **Journal of Management Inquiry**, v. 19, n. 1, p.14–20, 2010. Available at: https://doi.org/10.1177/1056492609347564

Proposta de *framework*: analisando estudos de economia circular com a teoria institucional

Proposal for a framework: analysing studies of circular economy with institutional theory

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ARTICLE- VARIA

RESUMO

A presente pesquisa teve por objetivo propor um *framework* para propiciar a análise de casos de implantação da Economia Circular (EC) sob a perspectiva da Teoria Institucional (TI). A elaboração desta estrutura teórica teve por base os níveis de operacionalização da Economia Circular e os tipos de mudanças isomórficas. Para demonstrar a aplicabilidade do *framework*, foi apresentada uma matriz que classifica 59 (cinquenta e nove) estudos de caso, em 9 quadrantes (3 x 3). Em seguida, os conteúdos dos papers foram discutidos, revelando estratégias e práticas para a mudança de comportamento institucional que alavanca rumo à implantação da EC, no nível micro, meso e macro. Portanto, os resultados deste trabalho contribuem não somente para a academia, ao introduzir uma nova forma de analisar estudos de caso de EC, como também para gestores, ao discutir casos implantados ou em fase de implantação.

Palavras-chave: Economia Circular. Embalagens em geral. Teoria Institucional. Isomorfismo.

ABSTRACT

This study proposes a framework to facilitate the Circular Economy (CE) implementation cases analysis from the Institutional Theory (IT) perspective. The development of this theoretical framework was based on the levels of operationalisation of the Circular Economy and the types of isomorphic changes. To demonstrate the framework's applicability, we present a matrix classifying 59 case studies into nine quadrants (3 x 3). Subsequently, the papers' contents were discussed, revealing

strategies and practices for institutional behavioural change that drive CE implementation at the micro, meso, and macro levels. Therefore, the results of this work contribute not only to academia by introducing a new way of analysing CE case studies but also to managers by discussing implemented or ongoing implementation cases.

Keywords: Circular economy. General packaging. Institutional theory. Isomorphism.

1 INTRODUÇÃO

Mercados desregulados, investimentos falhos e riscos de abastecimento levaram países inteiros a recessões econômicas cada vez mais duradouras. Além disso, o primitivo modelo mental consumista prevalece, tornando-se um desafio reduzir os impactos negativos do homem na Terra (GEISSDOERFER *et al*., 2017).

A pandemia da Covid-19 gerou uma crise sem precedentes e trouxe consequências econômicas negativas para vários setores de manufatura e serviços em geral (MALISZEWSKA *et al*., 2020). Autores como Everingham e Chassagne (2020) criticam o mito do crescimento perpétuo do capitalismo e citam o período pós-pandemia como uma oportunidade para repensar o modelo econômico atual.

Em relação ao alto padrão de produção e consumo dos produtos, Ghisellini *et al* (2016), por exemplo, alertam para a urgência de mudar os modelos de negócios para usar menos matéria-prima, energia e prolongar a vida útil dos produtos. Nesse sentido, a Economia Circular (EC) surge como alternativa. Visa substituir a filosofia linear do *take-make-dispose* por uma lógica circular na qual ações de redução, reutilização e reciclagem são executadas.

A busca pela eficiência do processo para atingir a circularidade dos produtos está presente em outras teorias de pensamento circular, como: biomimética, *design* regenerativo, *cradle to cradle* (C2C), entre outras (EMF, 2013). No entanto, a abordagem da EC é relativamente nova e carece de uma base teórica profunda (KORHONEN *et al*., 2018).

As organizações não apenas competem por recursos e clientes, mas também pelo poder de influenciar as políticas e assumir sua legitimidade institucional, portanto, as organizações devem frequentemente mudar para se adaptar (DIMAGGIO; POWELL, 1983). Nesse contexto, a Teoria Institucional (TI) é útil para essa compreensão macro dos ambientes organizacionais. A TI pode facilitar a colaboração entre as partes interessadas (SUDDABY, 2010), o que é fundamental para a viabilidade da cadeia de abastecimento circular e desenvolvimento econômico (NORTH, 1991).

Portanto, este artigo tem como objetivo aplicar a Teoria Institucional (TI) como base para analisar a operacionalização da Economia Circular na cadeia de embalagens. Após essa breve contextualização e apresentação do objetivo principal, este artigo está organizado da seguinte forma: o referencial teórico apresenta conceitos de Economia Circular, bem como a compreensão dos autores clássicos e contemporâneos sobre Teoria Institucional.

Em seguida, a seção de métodos demonstra as etapas percorridas e as classificações metodológicas. Posteriormente, apresenta-se o *framework* criado para analisar a implantação da EC pela ótica da Teoria Institucional e a mesma estrutura teórica é aplicada a fim de demonstrar sua utilidade. Assim, os resultados são apresentados em formato matricial e discutidos, expondo o conteúdo dos artigos analisados. Por fim, as considerações finais sintetizam as principais contribuições do paper, assim como assume-se limitação e são sugeridas pesquisas futuras.

2 REFERENCIAL TEÓRICO

2.1 ECONOMIA CIRCULAR DE EMBALAGENS

O principal objetivo da EC está ligado à prosperidade econômica com qualidade ambiental e equidade (KIRCHHERR *et al*., 2017). A *Ellen MacArthur Foundation* (EMF) tem colaborado extensivamente para divulgar o termo EC por meio de sua participação em várias edições do Fórum Econômico Mundial (EMF, 2013). A proposta da EC é não aceitar o conceito de resíduo, pois acredita-se que os materiais ainda têm valor, mesmo após o término do primeiro uso, sejam os produtos que possuem ciclos técnicos ou biológicos (GHISELLINI *et al*., 2016).

A fim de descrever as três escalas principais de operacionalização da Economia Circular, Ghisellini *et al*. (2016) categorizam diversos trabalhos posteriores utilizando essa divisão pedagógica (BRESSANELLI *et al*., 2021; LÜDEKE-FREUND *et al*., 2019). Em um nível micro, a operacionalização da EC é estudada em produtos, companhias ou consumidores. Já em um nível meso, estuda-se a operacionalização em um setor ou nos parques ecoindustriais e no nível macro, ela é avaliada em uma cidade, região ou mesmo entre países (GHISELLINI *et al*., 2016).

Entre os outros estudos também utilizaram essa classificação em suas pesquisas, cabe destacar Lüdeke-Freund *et al*. (2019). A partir da literatura, 26 (vinte e seis) modelos de negócios adotados em Economia Circular foram apresentados e suas estratégias de implantação foram discutidas. Outro trabalho que utiliza essa classificação de níveis de operação de EC é o realizado por Oliveira, Luna e Campos (2019). As autoras discutiram os desafios para implantação da Economia Circular a partir da análise dos canais reversos e da cadeia de suprimentos das embalagens de poliestireno no Brasil (OLIVEIRA *et al*., 2019).

Marrucci (2020) alerta para o fato de que mesmo diante do interesse crescente da comunidade científica pelo tema, o volume de Resíduos Sólidos Urbanos (RSU) tem aumentado mundo afora. Ainda segundo os autores, os 3 (três) níveis de operacionalização de EC têm sido analisados de forma separada (MARRUCCI, 2020). Jacobi *et al*. (2018) afirmam que é mais comum encontrar trabalhos dedicados ao nível micro e meso e ainda faltam *frameworks* que ambicionem integrar os três níveis.

No nível macro de análise, muitos trabalhos se debruçam sobre o gerenciamento de resíduos sólidos municipal (MARRUCCI, 2020). Por exemplo, Ferronato *et al*. (2019) investigam dois dos sistemas de reciclagem de dois países em desenvolvimento e constatam que a complexidade das práticas de EC aumenta à medida que o nível da escala aumenta. No intuito de integrar os diferentes níveis operacionais (micro, meso e macro), os autores reforçam a necessidade de políticas governamentais de incentivos e cobranças mais veementes, inclusão do setor informal que contribui de maneira marginalizada, parcerias público-privadas, programas de conscientização da população, entre outras medidas (FERRONATO *et al*., 2019).

A Figura 1 ilustra a segmentação que os pesquisadores utilizam para observar a transição para EC. Sendo essa divisão teórica, reitera-se que as práticas circulares que envolvem fases, como planejamento, compras, *design* e produção, precisam estar integradas para a manutenção dos ecossistemas e não prejuízo ao bem-estar social (MURRAY *et al*., 2015).

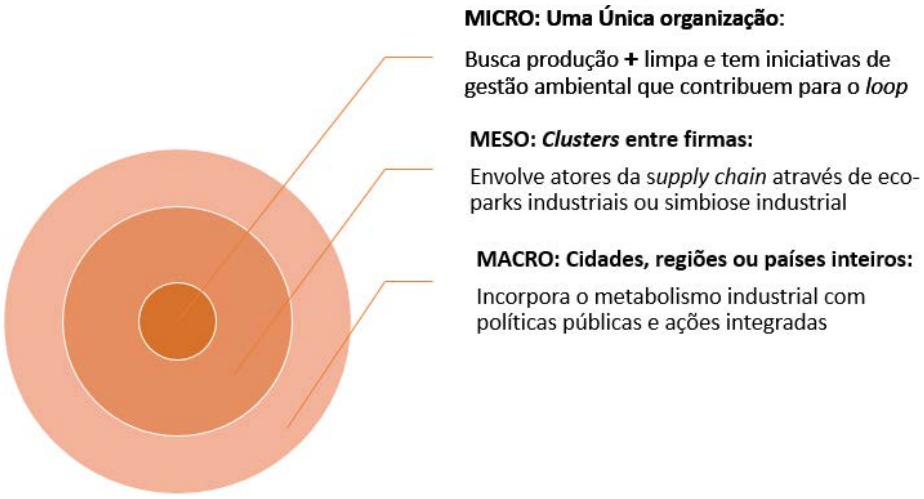


Figura 1 | Níveis de análise da operacionalização da Economia Circular

Fonte: Elaborado pelos autores com base em Murray et al. (2015).

As embalagens em geral são materiais, como papel, plástico, metal ou vidro, planejados, criados e utilizados para proteger e facilitar o transporte, armazenamento e comercialização de produtos. As embalagens de alimentos e bebidas, por exemplo, fornecem proteção e segurança para esse produto durante o transporte e armazenamento (BATISTA *et al*., 2018; LASO *et al*., 2016). No entanto, é importante lembrar que as embalagens em geral são um grande contribuinte para os resíduos sólidos urbanos (BOESEN *et al*., 2019; EMF, 2013).

Especificamente sobre embalagens, os países europeus são pioneiros em buscar o desenvolvimento sustentável por meio de uma mudança de paradigma: passando de uma economia linear para uma Economia Circular (RUBIO *et al*., 2019). Os países do bloco econômico da União Europeia buscam o conceito de circularidade no contexto da produção sustentável, ou seja, uma economia em que se preocupa em evitar a geração de resíduos e busque atividades de prolongamento da vida útil dos produtos, como o reúso e a reciclagem (LASO *et al*., 2016).

2.2 TEORIA INSTITUCIONAL

No intuito de compreender ideias e padrões de comportamento das instituições, bem como os valores e crenças dos indivíduos que impactam e são impactados por elas, North (1994) propõe a teoria de análise institucional. Para North (1994), as instituições têm papel fundamental no crescimento econômico. Afinal, elas fornecem confiança na determinação dos resultados, limitam escolhas individuais e se modificam ao longo do tempo, alterando o conjunto de opções disponíveis. As instituições, como costumes e regras, afetam os incentivos e desincentivos dos indivíduos, exercendo influência no conjunto de escolhas econômicas disponíveis.

Para obter crescimento econômico por meio da produtividade, faz-se importante entender as instituições e como moldam a economia, conforme sugerido pela teoria da análise institucional de North (1994). Assim, a Teoria Institucional (TI) pode contribuir para o amadurecimento dos debates rumo à operacionalização da EC. Entender organizações é fundamental para a ordem e o progresso, uma vez que elas formam a base da vida social, ou seja, ao compreendê-las, amplia-se a compreensão do sentido que as pessoas dão à vida e caminha-se rumo à estabilidade na sociedade (CAMPBELL, 2004). Há no campo organizacional um contínuo conflito de interesses que movimenta as instituições a realizarem mudanças, buscando a adaptação ou mesmo a sobrevivência no ambiente (DACIN *et al*., 2002). Mudanças organizacionais podem acontecer de forma radical ou incremental, sendo que em muitos momentos é mesmo difícil perceber que as mudanças estão em curso (CAMPBELL, 2004).

Durante a década de 1980, a Teoria Institucional se desenvolveu diante do desafio de compreender as mudanças cada vez mais intensas e frequentes que aconteciam (e continuam a acontecer) no mundo (SCOTT, 1991). O mesmo autor ainda atribui à reconceitualização dos ambientes organizacionais a maior contribuição dos teóricos institucionais (SCOTT, 1991). Os ambientes poderiam ser divididos em técnicos e institucionais, sendo que o primeiro envolvia troca de informação e tecnologia complexa enquanto o ambiente institucional envolvia regras formais e informais, categorias socialmente definidas (MEYER; ROWAN, 1977; SCOTT, 1991).

Participar de um ambiente institucionalizado é uma característica das organizações na sociedade moderna, uma vez que essas instituições são compostas por profissionais, dirigidos por políticas e programas que visam à racionalidade e a eficiência no uso dos recursos. As organizações precisam crescer em legitimidade para aumentar sua possibilidade de sobrevivência (MEYER; ROWAN, 1977) e esses campos estruturados tendem a fazer com que as organizações adotem comportamento semelhante. O isomorfismo, portanto, surge como um conceito que traduz esse ímpeto das unidades organizacionais buscarem atitudes semelhantes, já que enfrentam problemas parecidos (DIMAGGIO; POWELL, 1983).

Além de tentar superar desafios naturais do mercado, as organizações precisam se relacionar com outras organizações o tempo todo. Organizações não somente disputam recursos e clientes, mas também poder para influenciar políticas e assumir sua legitimidade institucional, por isso, constantemente as organizações devem mudar para adaptar-se. Dessa forma, o isomorfismo torna-se importante para compreender o que tornam as empresas tão similares (DIMAGGIO; POWELL, 1983).

Dimaggio e Powell (1983) listam três mecanismos para diferenciar as mudanças isomórficas institucionais, são eles: 1) isomorfismo coercitivo, que deriva de influências políticas, por exemplo quando o Estado induz ou força organizações a adotar medidas ou mudar comportamentos; 2) isomorfismo mimético, tendência à homogeneização oriunda de respostas padronizadas à incerteza, normalmente ocorre quando organizações copiam outras bem-sucedidas e; 3) isomorfismo normativo, que normalmente surge de projetos de profissionalização, motivados a respeitar obrigações surgidas e cobradas pela sociedade. Cabe ressaltar que os tipos não são puros, ou seja, normalmente não são exclusivos, e sim interativos.

Suddaby (2010) crê na importância das teorias para o fomento de mudanças organizacionais que sejam mais produtivas, o autor afirma que teorias são ferramentas. Na opinião desse autor, a Teoria Institucional é útil para essa compreensão macro dos ambientes organizacionais e esse paradigma pode, inclusive, levar à facilidade de colaboração entre *stakeholders* e consequentemente facilitar o acesso a recursos.

As instituições, portanto, nascem a partir da interação política, econômica e social. Assim, a institucionalização é o processo de tornar instituições amplamente conhecidas e perpetuá-las no longo prazo. Os *frameworks* que amparam a institucionalização apresentam potencial de contribuir para o crescimento econômico já que reduzem custo e aumentam a cooperação entre os agentes econômicos (NORTH, 1991).

3 MÉTODOS E TÉCNICAS DE PESQUISA

Diante do objetivo de propor um *framework* para propiciar a análise de casos de implantação da Economia Circular (EC), primeiramente faz-se necessário evidenciar a importância da criação dessas estruturas teóricas. Um *framework* é uma ferramenta para auxiliar no entendimento de complexidades presentes no mundo real. Portanto, são criações de pesquisadores para a compreensão de fenômenos que ainda carecem de análise. A criação desses modelos contribui para esclarecer o relacionamento entre elementos, inclusive possíveis relações de causa-efeito (MUNCK *et al*., 2013).

De acordo com Shehabuddeen, Probert e Phaal (2000), *frameworks* podem ser de diferentes tipos: simples, elaborados, descritivos ou causais. Estruturas teóricas se diferem de um simples mapeamento, na medida em que são abstrações de acontecimentos nada estáticos, dinâmicos.

Ainda segundo Shehabuddeen, Probert e Phaal (2000), o processo de elaboração de uma estrutura teórica envolve a identificação de propósitos específicos. Posteriormente, monta-se uma estrutura de relacionamentos com a criação de categorias. Assim, 3 (três) perguntas foram elaboradas para nortear a classificação bibliográfica: 1) Quais os níveis de operação da Economia Circular de embalagens são mais estudados? 2) Quais os mecanismos de mudança institucional rumo à Economia Circular de embalagens são mais estudados? 3) Quais as tendências e as lacunas de pesquisa ainda existentes?

A Figura 2 evidencia o *framework* criado pelos autores do presente trabalho.

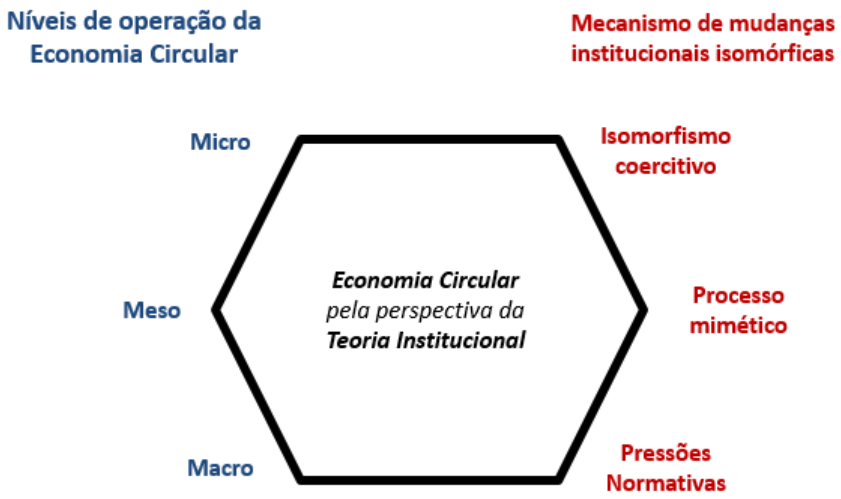


Figura 2 | *Framework* para análise da Economia Circular pela perspectiva da Teoria Institucional

Fonte: Elaboração própria.

A Figura 2 relaciona uma teoria administrativa já consolidada (Teoria Institucional) com uma ainda nascente e de uso crescente pelos acadêmicos da área da engenharia, gestão (*management*), ciências sociais aplicadas e ambientais (Economia Circular). Essa estrutura criada permite que analistas reflitam e investiguem sobre os níveis de operação da EC, bem como sobre os mecanismos de mudança institucional que poderiam contribuir para a institucionalização dessas práticas que contribuem para o desenvolvimento sustentável.

A próxima seção, destinada à apresentação e discussão dos resultados, fez uso da Revisão Integrativa de Literatura realizada por Cerqueira-Streit *et al*. (2022), a fim de aplicar o *framework* elaborado. Trata-se de uma revisão que incorporou artigos teóricos e empíricos, artigos seminais e mais recentes publicados em periódicos internacionais sobre Economia Circular de embalagens (*Circular Economy of packaging*).

É importante ressaltar que a análise de conteúdo foi do tipo categorial temática e segundo Bardin (2011), ou seja, um fragmento de texto pode dar origem a uma categoria de análise. Caso esse trecho seja homogêneo, exaustivo e pertinente, um determinado trecho da comunicação pode ser considerado uma categoria de análise.

Ainda que os três tipos de isomorfismo se misturem na prática, Dimaggio e Powell (1983) reforçam que a divisão teórica pode facilitar a análise das diferentes pressões. Assim, os autores da presente pesquisa analisaram todos os 59 (cinquenta e nove) estudos de caso que fazem parte da amostra da

Revisão Integrativa de Literatura conduzida por Cerqueira-Streit *et al*. (2022). Essa RIL está alinhada aos interesses da presente pesquisa, os critérios de busca foram sistemáticos e, assim, possibilitam a seguinte classificação: quanto ao nível de operacionalização da EC de Embalagens (micro, meso e macro) e quanto aos mecanismos para uma mudança institucional rumo à EC de Embalagens (isomorfismo coercitivo, mimético ou normativo).

4 RESULTADOS E DISCUSSÃO

O entendimento do presente trabalho sobre EC vai ao encontro dos trabalhos que representam a EC como uma mudança de paradigma. Essa mudança visa estimular a prevenção de geração de resíduos e a economia de energia e de materiais ao fechar o ciclo produtivo, e acredita-se que ela pode ser implementada nos níveis micro, meso ou macro. No nível micro, empresas e consumidores são estudados, enquanto no nível meso as mudanças dos agentes econômicos que participam de um mesmo setor são analisadas sob a perspectiva simbiótica. No nível macro, por sua vez, estudam-se cidades, regiões ou países na intenção de comparar atitudes governamentais, empresariais e da sociedade de uma forma geral.

É importante mencionar o fato de os artigos terem sido classificados de acordo com o *lócus* onde os estudos foram aplicados (micro, meso ou macro) e a menção dos autores a possíveis comportamentos isomórficos (coercitivo, mimético ou normativo). Por exemplo, o de Kuo *et al*. (2019) foi classificado na presente estrutura como do tipo micro e coercitivo. Afinal, os pesquisadores entrevistaram gestores de uma só planta fabril de painéis LCD (*Liquid Crystal Display*) no intuito de investigar a possibilidade de mudar para uma logística menos degradante, em que as embalagens fossem de maior qualidade e maior possibilidade de reutilização.

Ao longo do trabalho, os pesquisadores enfatizam a importância da regulação para forçar as empresas a reestruturar a logística e *modus operandi* quanto à segurança do trabalho, eficiência, atividades de armazenamento e manuseio do produto. A regulação pode inclusive alterar a forma com que as empresas se comunicam e instruem os clientes para o adequado consumo, manejo e descarte (KUO *et al*., 2019).

Ao realizar 5 (cinco) entrevistas com experts e 8 (oito) observações não participantes em um hospital da cidade de Antuérpia (Bélgica), o estudo de Harding *et al*. (2021) fez importantes considerações sobre a gestão de resíduos de embalagens no ambiente hospitalar. Primeiramente sobre a quantidade e qualidade das diversas embalagens geradas, como as plásticas, de papel, metal e embalagens multicamadas (que mesclam mais de um material).

Trazem também reflexões sobre a importância dos centros de esterilização e o uso das embalagens para proteção após esterilização (HARDING *et al*., 2021). Os autores ressaltam a importância de "ecologizar" os hospitais, inclusive as salas de cirurgia, no intuito de reduzir os desperdícios e otimizar processos de reutilização (através da esterilização) e reciclagem, quando possível. Na opinião dos autores, esse hospital está à frente dos demais ao buscar ações nesse sentido e, por isso, é um caso a ser imitado. Inclusive, citam que o hospital agora é um exemplo a ser seguido. A presença de práticas circulares bem-sucedidas e esse estímulo ao *benchmarking* é o que caracteriza o estímulo ao isomorfismo mimético (HARDING *et al*., 2021).

Entender o comportamento do consumidor pode ser considerado fomento para investigações no nível micro de operação da EC, uma vez que o sucesso desse novo paradigma também depende de práticas individuais. Abuabara *et al*. (2021) entrevistaram 40 (quarenta) participantes da cadeia de cápsulas de café (embalagens de plástico e alumínio) com o objetivo de compreender os interesses dos consumidores em aspectos ligados à logística reversa e gestão ambiental. Como principal *output*, os autores elaboraram um *framework* teórico para auxiliar gestores a tomar decisão com base nos pensamentos e ações do consumidor final.

O engajamento da comunidade tende a trazer impactos coletivos positivos para o meio ambiente e o bem-estar. Quando esses atores pressionam por projetos mais profissionais das empresas, que façam programas sérios de logística reversa ou demonstrem preocupação com a gestão de resíduos, fica evidenciado a importância do mecanismo normativo no processo de institucionalização da EC. É necessário estimular o comportamento consciente e a responsabilidade civil para que os consumidores optem mais frequentemente por produtos e empresas "ecoamigáveis", valorizando as companhias que agem adequadamente e gerando uma competição por ações mais sustentáveis (ABUABARA *et al*., 2019).

O Quadro 1 apresenta a matriz em que foram classificados os 59 (cinquenta e nove) estudos de caso sobre EC de embalagens, demonstrando a aplicação do *framework* proposto.

Quadro 1 | Estudos de caso em Economia Circular de embalagens analisados conforme a Teoria Institucional

		Mecanismo de mudança institucional isomórfica		
		Isomorfismo coercitivo	**Processo Mimético**	**Processo Normativo**
Níveis de operacionalização da Economia Circular	Micro	Ameli *et al*. (2019); Guerin (2020b); Kuo *et al*. (2019); Laso *et al*. (2018).	Guerin (2020a); Harding *et al*. (2021); Leissner; Ryan-Fogarty (2019); Marrucci *et al.* (2020); Principato *et al*. (2019); Selina *et al*. (2021).	Abuabara *et al*. (2019); Ermolaeva; Rybakova (2019); Jang *et al*. (2020); Marotta *et al.* (2019); Rizzo *et al.* (2017); Stephan *et al*. (2020); Virsta *et al*. (2020).
	Meso	Bruno *et al*. (2020); Kazulyte; Kruopiene (2018); Laso *et al*. (2016).	Bishop *et al*. (2021); Friedrich *et al.* (2020); Niero *et al*. (2017); Usapein; Chavalparit (2014).	Casarejos *et al*. (2018); Husgafvel *et al.* (2018); Mura *et al.* (2020).
	Macro	Andreasi Bassi *et al*. (2020); Bogusz *et al*. (2021); Ezeudu; Ezeudu (2019); Foschi *et al*. (2021); Fuss *et al*. (2021); Guarnieri *et al*. (2020); Kranzinger *et al*. (2017); Kudela *et al.* (2020); Polygalov *et al*. (2021); Rigamonti *et al*. (2019); Roithner; Rechberger (2020); Rubio *et al*. (2019); Rutkowski (2020); Thabit *et al*. (2020).	Aznar-Sánchez *et al*. (2020); Faussone (2018); Fitch-Roy *et al*. (2021); Jeswani *et al*. (2021); Nevrlý *et al*. (2021); Nimmegeers; Billen (2021); Oyelola *et al*. (2017); Pluskal *et al*. (2021); Somplák *et al*. (2019); Van Eygen *et al*. (2018)	Allison *et al*. (2021); Lucia; Pazienza (2019); Jang *et al*. (2020); Kakadellis *et al*. (2021); Miliute-Plepiene; Plepys (2015); Roche Cerasi *et al.* (2021); Simoens; Leipold (2021); Taffuri *et al*. (2021).

Fonte: Elaboração própria.

Após a discussão de alguns artigos que trataram o nível micro com distintos mecanismos de mudança isomórfica e a exposição do Quadro 1, os próximos parágrafos evidenciam os trabalhos que abordaram os níveis meso e macro.

Ao tratar da cadeia da indústria do pescado, Laso *et al*. (2016) utilizaram a Avaliação do Ciclo de Vida (ACV) para identificar o melhor tratamento para os resíduos da anchova em lata: a cabeça, espinhos, escamas e a carne não aproveitada no enlatado. Do inglês *Life Cycle Assessment* (LCA), a ACV é uma ferramenta quantitativa inspirada nos princípios da ecoeficiência, que permite a diminuição da pegada ambiental ao controlar a utilidade do produto.

As partes do peixe não aproveitadas no produto principal (cabeça e espinhos) podem ser utilizadas para a produção de farinha e óleo de peixe. Os autores afirmam ainda que as escamas e a pele dos peixes podem ser valorizadas na produção de bioplásticos, que serviriam para embalagem, pois já existe tecnologia disponível para tal aproveitamento (LASO *et al*., 2016).

Pensar na substituição das embalagens de uso único, que seriam descartadas logo após o primeiro uso, faz parte da busca por soluções que a EC propõe. A destinação para aterro ou a incineração foram consideradas as menos vantajosas, tendo em vista os altos encargos governamentais. É nesse ponto que o trabalho se enquadra como coercitivo, afinal, os autores indicam que a busca do setor pela eliminação do conceito de lixo é motivada pela tentativa de cumprimento às legislações ambientais europeias (LASO *et al*., 2016).

Um dos trabalhos classificados como meso (por ser aplicado em um determinado setor industrial), cujo mecanismo de isomorfismo é considerado mimético, foi o de Niero *et al*. (2017). Nessa oportunidade, os autores apresentam um quadro com a combinação de Avaliação do Ciclo de Vida com certificação *Cradle to Cradle* (C2C) para latas de alumínio da indústria cervejeira Carlsberg. Fica mais evidente que adequações como essa são motivadas pelo fato de a empresa estudada não querer ficar atrás da concorrência, o que caracteriza um isomorfismo mimético.

Ao conquistar uma certificação como a C2C, empresas progridem rumo à EC e podem comprovar para todo o mercado, auxiliando-as a conquistar vantagem competitiva. Um dos principais desafios para a implementação de estratégias de EC é o *design* de produto, ou seja, que o produto desde o início seja pensado e construído para facilitar a reutilização, o reúso, o recondicionamento, entre outros Rs (NIERO *et al*., 2017).

Ao afirmar a importância da certificação C2C, os autores citam algumas vezes sobre o pioneirismo da indústria de bebidas e como diversas outras estão buscando adaptação (não somente a Carlsberg e sua cadeia). Inclusive, o entendimento do que os autores chamam de "comunidade Carlsberg" facilita a compreensão do nível meso, que ambiciona caminhar rumo à EC (NIERO *et al*., 2017).

Além da legislação forte e incentivos para adequação da indústria, a cobrança dos clientes é fundamental. Por meio da aplicação de questionários e de entrevistas com empresas grandes e pequenas, Husgafvel *et al*. (2018) investigaram as oportunidades e desafios do reaproveitamento da madeira. Além da indústria moveleira e marcenaria, madeira é um material que pode ser usado na serração, construção de *pallets* e fabricação de embalagens.

Esse trabalho foi classificado como normativo, uma vez que os autores reiteram a importância da sociedade para exigir que empresas aumentem seu grau de profissionalismo e leve em consideração as questões de sustentabilidade. Na Finlândia, onde esse caso foi estudado, acredita-se que a opinião pública tenha papel fundamental para que as empresas vejam na responsabilidade corporativa uma possibilidade de agregar valor aos seus negócios (HUSGAFVEL *et al*., 2018).

Ao analisar a implantação da primeira fase do Acordo Setorial de embalagens em geral no Brasil, Guarnieri *et al*. (2020) utilizaram-se da análise documental e de entrevistas semiestruturadas com representantes do governo, empresas e catadores de materiais recicláveis. Apesar de o termo EC não estar presente no corpo da Lei Nacional de Resíduos Sólidos (nº 12.305/10), acredita-se que seus objetivos, princípios e instrumentos estejam alinhados com o que defende esse novo paradigma (BRASIL, 2010).

Em sua primeira fase, o acordo setorial apresentou resultados interesses quanto ao apoio às cooperativas de catadores (quem de fato recolhe, tria e viabiliza o envio das embalagens para reciclagem), instalação de Pontos de Entrega Voluntária (PEVs) e programas de educação ambiental para a população. Entretanto, os autores pontuam que essa fase aconteceu como um piloto, uma vez que foi implementada somente em 12 cidades brasileiras, aquelas que abrigariam a Copa do Mundo em 2014 e, portanto, possuíam maior infraestrutura logística (GUARNIERI *et al*., 2020).

Os autores defendem o isomorfismo coercitivo na medida em que acreditam que a lei deve ser implementada em todo o território brasileiro, respeitando os princípios da responsabilidade compartilhada e da inclusão socioprodutiva dos catadores (GUARNIERI *et al*., 2020).

A incrível versatilidade do plástico há décadas é apreciada pela indústria e por consumidores. A composição desses polímeros tem contribuído de forma significativa para o acondicionamento de alimentos, e em especial o uso dos plásticos multicamadas (*multilayer*) são úteis para evitar que o alimento tenha contato com luz, umidade ou oxigênio. Entretanto, segundo Nimmegeers e Billen (2021), exatamente essas propriedades que tornam o plástico um material polivalente, e que têm acarretado em mais complexidade para a cadeia da reciclagem.

Mediante análises estatísticas desenvolvidas pelos autores, esse trabalho investigou de forma ampla os resíduos de embalagens plásticas na Bélgica. Questões relacionadas às complexidades na coleta (pelo uso difuso) e reciclabilidade (devido às multicamadas) foram discutidas e os autores apresentaram os fluxos de resíduos que mais contribuem para a complexidade da separação. Desse modo, os autores recomendam que esse modelo estatístico seja aplicado a outros estudos de caso, caracterizando a ideia de imitação e aplicação de boas práticas típicas do mecanismo mimético de isomorfismo (NIMMEGEERS; BILLEN, 2021).

Por fim, cabe evidenciar pelo menos um trabalho incluído entre os que abrangeram o nível macro de Economia Circular e defenderam o isomorfismo normativo para sua institucionalização. Por mais que a Responsabilidade Estendida do Produtor (REP) esteja presente na legislação alemã desde a década de 1990, Simoens e Leipold (2021) afirmam que ainda existem muitos entraves para sua plena operação.

Assim como o brasileiro, no setor de embalagens na Alemanha há presença de diversas coalizões que defendem seus interesses de forma veemente. Esses grupos são formados por legisladores, produtores, distribuidores e empresas já consolidadas de gestão de resíduos (SIMOENS; LEIPOLD, 2021).

Na Alemanha, o setor de embalagem também pode ser dividido entre: os que defendem a privatização do setor e os que defendem a maior força para a municipalidade na gestão de resíduos. Entre os principais desafios relatados, os autores afirmam que os consumidores alemães ainda apresentam baixo comportamento pró-coleta seletiva e que mais ações de conscientização são necessárias. Os resultados desse paper indicam que a real transição para a EC acontecerá de forma gradual e passa necessariamente pelo aumento da cobrança dos cidadãos por sistemas mais eficientes de coleta e reciclagem, seja operacionalizado pelo governo ou empresas (SIMOENS; LEIPOLD, 2021).

5 CONSIDERAÇÕES FINAIS

O modelo econômico vigente apresenta poucos indícios de sustentabilidade. Afinal, os recursos naturais finitos estão em crescente escassez, as mazelas sociais, como fome e falta de saneamento básico, continuam presentes e os problemas econômicos, como desemprego e desigualdades entre classes, não param de aumentar. Assim, há urgência na necessidade de uma mudança de paradigma para que o atual modelo de produção e consumo seja substituído por uma proposta menos degradante e, consequentemente, mais duradoura.

Surge, portanto, a Economia Circular como uma nova maneira de se fazer negócio, em que preze pelo menor uso de matéria-prima e energia, assim como a ampliação da utilidade dos produtos e seus componentes. O objetivo central deste artigo, por conseguinte, foi elaborar um *framework* capaz de analisar a operacionalização da Economia Circular na cadeia de embalagens, a partir de casos empíricos já publicados e sob a ótica da Teoria Institucional.

Os resultados da presente pesquisa podem ser sintetizados na Figura 2 e no Quadro 1. A Figura 2 evidencia o *framework* criado para análise da Economia Circular pela perspectiva da Teoria Institucional, enquanto o Quadro 1 demonstra como aplicá-lo. Com esse objetivo, criou-se uma matriz com os 59 estudos de caso em Economia Circular de embalagens que foram analisados sob a ótica da Teoria Institucional (Quadro 1).

O conteúdo de alguns desses artigos foram debatidos a fim de demonstrar a classificação de cada um deles e apresentar ferramentas como Avaliação do Ciclo de Vida (ACV), certificação *Cradle to Cradle* (C2C) e Responsabilidade Estendida do Produtor (REP). Ressalta-se que o critério adotado foi apresentar pelo menos um artigo de cada um dos quadrantes. Assim, foram discutidos 9 (nove) artigos oriundos do cruzamento 3 x 3 (três vezes três) das 6 (seis) categorias temáticas em questão (micro, meso, macro, isomorfismo coercitivo, mimético e normativo).

Apesar da existência de diversos estudos de caso, nos mais diversos níveis de análise e mudança isomórfica indicada, o tema está longe de ser esgotado. Este trabalho evidencia a variedade de lugares, métodos, escopo e materiais diferentes que pesquisas em EC de embalagens podem abranger.

A principal limitação deste estudo se deve ao fato de se basear puramente em argumentos com base na interpretação dos analistas, que propiciou a classificação dos artigos. Apesar dessa limitação, o artigo estimula reflexões sobre a prática da Economia Circular de Embalagens à luz da Teoria Institucional e, durante a discussão dos casos, demonstra a aplicação de estratégias e ferramentas que levam aos 3Rs (redução, reutilização e reciclagem), assim como debate seus resultados. Já a principal contribuição teórica deste artigo é ter criado uma estrutura capaz de analisar casos reais de Economia Circular. Em adicional, este trabalho mostrou-se útil ao preencher a lacuna levantada por Korhonen *et al*. (2018). Esses autores alertaram que estudar a Economia Circular à luz de uma teoria seria uma rica contribuição para a área. Adicionalmente, autores como Fischer e Pascucci (2017) indicaram a necessidade de a EC ser estudada com base em teorias científicas já consolidadas, como foi realizado com a Teoria Institucional.

Estudos futuros podem aplicar o *framework* apresentado a fim de avaliar outros trabalhos de EC, não se limitando aos que tratam de materiais recicláveis. Espera-se ainda que novos estudos com base em outras teorias administrativas sejam escritos e publicados, assim, talvez a Economia Circular ganhe a robustez necessária para continuar crescendo, não só no meio acadêmico, mas também nas organizações públicas e privadas.

REFERÊNCIAS

ABUABARA, L.; PAUCAR-CACERES, A.; BURROWES-CROMWELL, T. Consumers' values and behaviour in the Brazilian coffee-in-capsules market: promoting circular economy. **International Journal of Production Research**, v. 57, n. 23, p. 7269–7288, 2019. Available at: https://doi.org/10.1080/00207543.2019.1629664

ALLISON, A. L. *et al*. Barriers and enablers to buying biodegradable and compostable plastic packaging. **Sustainability** (Switzerland), v. 13, n. 3, p. 1–15, 2021. Available at: https://doi.org/10.3390/su13031463

AMELI, M.; MANSOUR, S.; AHMADI-JAVID, A. A simulation-optimization model for sustainable product design and efficient end-of-life management based on individual producer responsibility. **Resources, Conservation and Recycling**, v. 140, n. 1, p. 246–258, 2019. Available at: https://doi.org/10.1016/j.resconrec.2018.02.031

ANDREASI BASSI, S. *et al*. Extended producer responsibility: How to unlock the environmental and economic potential of plastic packaging waste? **Resources, Conservation and Recycling**, v. 162, n. 1, 105030, 2020. Available at: https://doi.org/10.1016/j.resconrec.2020.105030

AZNAR-SÁNCHEZ, J. A. *et al*. Identification of opportunities for applying the circular economy to intensive agriculture in Almería (South-East Spain). **Agronomy**, v. 10, n. 10, 2020. Available at: https://doi.org/10.3390/agronomy10101499

BARDIN, L. **Análise de Conteúdo**. Edições 70, 2011.

BATISTA, L. *et al*. In search of a circular supply chain archetype – a content-analysis-based literature review. **Production Planning and Control**, v. 29, n. 6, p. 438–451, 2018. Available at: https://doi.org/10.1080/09537287.2017.1343502

BOESEN, S.; BEY, N.; NIERO, M. Environmental sustainability of liquid food packaging: Is there a gap between Danish consumers' perception and learnings from life cycle assessment? **Journal of Cleaner Production**, v. 210, p. 1193–1206, 2019. Available at: https://doi.org/10.1016/j.jclepro.2018.11.055

BOGUSZ, M. *et al*. The concept of zero waste in the context of supporting environmental protection by consumers. **Energies**, v. 14, n. 18, 2021. Available at: https://doi.org/10.3390/en14185964

BRASIL. **Lei n. 12.305, de 2 de agosto de 2010**. Institui a Política Nacional de Resíduos Sólidos, 2010.

BRUNO, G. *et al*. Decarbonization of the Cement Industry – Production of Solid Fuel From Non-Hazardous Waste. **Procedia Environmental Science, Engineering and Management**, v. 7, n. 2, p. 277–286, 2020.

CAMPBELL, J. L. **Institutional Change and Globalization**. In Princeton: University Press, 2004.

CASAREJOS, F. *et al*. Rethinking packaging production and consumption vis-à-vis circular economy: a case study of compostable cassava starch-based material. **Journal of Cleaner Production**, v. 201, p. 1019–1028, 2018. Available at: https://doi.org/10.1016/j.jclepro.2018.08.114

CERQUEIRA-STREIT, J. A.; OLIVEIRA, L. **Contribuições da Gestão de Resíduos de Embalagens para a Economia Circular**: uma revisão integrativa da literatura. XXIII SIMPOI - SIMPÓSIO DE ADMINISTRAÇÃO DA PRODUÇÃO, LOGÍSTICA E OPERAÇÕES INTERNACIONAIS. São Paulo-SP, 2022.

DACIN, T.; GOODSTEIN, J.; SCOTT, R. Institutional Theory and Institutional change: introduction to special research forum. **Academy of Management Journal**, v. 45, n. 1, p. 45–57, 2002.

DIMAGGIO, P. J.; POWELL, W. W. The Iron Cage Revisited: institutional isomorphism and collective rationality in organizational fields. **American Sociological Review**, v. 48, n. 2, p. 147–160, 1983. Available at: https://doi.org/10.2307/2095101

EMF. Ellen MacArthur Foundation. Towards the Circular Economy Vol. 1: Economic and business rationale for an accelerated transition. **Ellen Macarthur Foundation**, v. 1, p.1–96, 2013. Available at: https://doi.org/10.1162/108819806775545321

EVERINGHAM, P.; CHASSAGNE, N. Post Covid-19 ecological and social reset: moving away from capitalist growth models towards tourism as Buen Vivir. **Tourism Geographies**, v. 1, p. 1–12, 2020. Available at: https://doi.org/10.1080/14616688.2020.1762119

EZEUDU, O. B.; EZEUDU, T. S. Implementation of circular economy principles in industrial solid waste management: case studies from a developing economy (Nigeria). **Recycling**, v. 4, n. 4, 2019. Available at: https://doi.org/10.3390/recycling4040042

FAUSSONE, G. C. Transportation fuel from plastic: two cases of study. **Waste Management**, v. 73, p. 416–423, 2018. Available at: https://doi.org/10.1016/j.wasman.2017.11.027

FERRONATO, N. *et al*. Introduction of the circular economy within developing regions: a comparative analysis of advantages and opportunities for waste valorization. **Journal of Environmental Management**, v. 230, n. 1, p. 366–378, 2019. Available at: https://doi.org/10.1016/j.jenvman.2018.09.095

FISCHER, A.; PASCUCCI, S. Institutional incentives in circular economy transition: the case of material use in the Dutch textile industry. **Journal of Cleaner Production**, v. 155, p. 17–32, 2017. Available at: https://doi.org/10.1016/j.jclepro.2016.12.038

FITCH-ROY, O.; BENSON, D.; MONCIARDINI, D. All around the world: assessing optimality in comparative circular economy policy packages. **Journal of Cleaner Production**, v. 286, 125493, 2021. Available at: https://doi.org/10.1016/j.jclepro.2020.125493

FOSCHI, E.; D'ADDATO, F.; BONOLI, A. Plastic waste management: a comprehensive analysis of the current status to set up an after-use plastic strategy in Emilia-Romagna Region (Italy). **Environmental Science and Pollution Research**, v. 28, n. 19, p. 24328–24341, 2021. Available at: https://doi.org/10.1007/s11356-020-08155-y

FRIEDRICH, K. *et al*. Benchmark analysis for plastic recyclates in Austrian waste management. **Detritus**, v. 9, p. 105–112, 2020. Available at: https://doi.org/10.31025/2611-4135/2019.13869

FUSS, M.; BARROS, R. T. V.; POGANIETZ, W. R. The role of a socio-integrated recycling system in implementing a circular economy – The case of Belo Horizonte, Brazil. **Waste Management**, v. 121, p. 215–225, 2021. Available at: https://doi.org/10.1016/j.wasman.2020.12.006

GEISSDOERFER, M. *et al*. Circular business models: a review. **Journal of Cleaner Production**, v. 277, 123741, 2020. Available at: https://doi.org/10.1016/j.jclepro.2020.123741

GHISELLINI, P.; CIALANI, C.; ULGIATI, S. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. **Journal of Cleaner Production**, v. 114, p. 11–32, 2016. Available at: https://doi.org/10.1016/j.jclepro.2015.09.007

GUARNIERI, P.; CERQUEIRA-STREIT, J.; BATISTA, L. Reverse logistics and the sectoral agreement of packaging industry in Brazil towards a transition to circular economy. **Resources, Conservation and Recycling**, v. 153, 104541, 2020. Available at: https://doi.org/10.1016/j.resconrec.2019.104541

GUERIN, T. F. Evaluating treatment pathways for managing packaging materials from construction of a solar photovoltaic power station. **Waste Management and Research**, v. 38, n. 12, p. 1345–1357, 2020. Available at: https://doi.org/10.1177/0734242X20939627

HARDING, C. *et al*. Design opportunities to reduce waste in operating rooms. **Sustainability** (Switzerland), v. 13, n. 4, p. 1–14, 2021. Available at: https://doi.org/10.3390/su13042207

HUSGAFVEL, R. *et al*. Forest sector circular economy development in Finland: a regional study on sustainability driven competitive advantage and an assessment of the potential for cascading recovered solid wood. **Journal of Cleaner Production**, v. 181, p. 483–497, 2018. Available at: https://doi.org/10.1016/j.jclepro.2017.12.176

JACOBI, N. *et al*. Providing an economy-wide monitoring framework for the circular economy in Austria: status quo and challenges. **Resources, Conservation and Recycling**, v. 137, p. 156–166, 2018. Available at: https://doi.org/10.1016/j.resconrec.2018.05.022

JANG, Y. C. *et al*. Recycling and management practices of plastic packaging waste towards a circular economy in South Korea. **Resources, Conservation and Recycling**, v. 158, 104798, 2020. Available at: https://doi.org/10.1016/j.resconrec.2020.104798

KAKADELLIS, S.; WOODS, J.; HARRIS, Z. M. Friend or foe: stakeholder attitudes towards biodegradable plastic packaging in food waste anaerobic digestion. **Resources, Conservation and Recycling**, v. 169, 2021. Available at: https://doi.org/10.1016/j.resconrec.2021.105529

KIRCHHERR, J.; REIKE, D.; HEKKERT, M. Conceptualizing the circular economy: an analysis of 114 definitions. **Resources, Conservation and Recycling**, v. 127, p. 221–232, 2017. Available at: https://doi.org/10.1016/j.resconrec.2017.09.005

KORHONEN, J.; HONKASALO, A.; SEPPÄLÄ, J. Circular Economy: the concept and its limitations. **Ecological Economics**, v. 143, p. 37–46, 2018. Available at: https://doi.org/10.1016/j.ecolecon.2017.06.041

KUO, T. C. *et al*. The circular economy of LCD panel shipping in a packaging logistics system. Resources, Conservation and Recycling, v. 149, p. 435–444, 2019. Available at: https://doi.org/10.1016/j.resconrec.2019.06.022

LASO, J. *et al*. Waste management under a life cycle approach as a tool for a circular economy in the canned anchovy industry. **Waste Management and Research**, v. 34, n. 8, p. 724–733, 2016. Available at: https://doi.org/10.1177/0734242X16652957

LASO, J. *et al*. Introducing the Green Protein Footprint method as an understandable measure of the environmental cost of anchovy consumption. **Science of the Total Environment**, v. 621, p. 40–53, 2018. Available at: https://doi.org/10.1016/j.scitotenv.2017.11.148

LUCIA, C.; PAZIENZA, P. Market-based tools for a plastic waste reduction policy in agriculture: a case study in the south of Italy. **Journal of Environmental Management**, v. 250, n. 1, 109468, 2019. Available at: https://doi.org/10.1016/j.jenvman.2019.109468

LÜDEKE-FREUND, F.; GOLD, S.; BOCKEN, N. A Review and Typology of Circular Economy Business Model Patterns. **Journal of Industrial Ecology**, v. 23, n. 1, p. 36–61, 2019. Available at: https://doi.org/10.1111/jiec.12763

MALISZEWSKA, M.; MATTOO, A.; MENSBRGGHE, D. The Potential Impact of Covid-19 on GDP and Trade A Preliminary Assessment. **Policy Research Working Paper**, v. 9211, p. 1–24, 2020.

MAROTTA, D. *et al*. Disposal and reuse in the circular economy: reduction of plastic materials in products of large-scale distribution. **Procedia Environmental Science, Engineering and Management**, v. 6, n. 1, p. 103–109, 2019.

MARRUCCI, L.; MARCHI, M.; DADDI, T. Improving the carbon footprint of food and packaging waste management in a supermarket of the Italian retail sector. **Waste Management**, v. 105, p. 594–603, 2020. Available at: https://doi.org/10.1016/j.wasman.2020.03.002

MILIUTE-PLEPIENE, J.; PLEPYS, A. Does food sorting prevents and improves sorting of household waste? A case in Sweden. **Journal of Cleaner Production**, v. 101, p.182–192, 2015. Available at: https://doi.org/10.1016/j.jclepro.2015.04.013

MUNCK, L. *et al*. Em busca da sustentabilidade organizacional: a proposição de um framework. **Revista Alcance**, v. 20, n. 4, p. 460-477, 2013.

MURRAY, A.; SKENE, K.; HAYNES, K. The Circular Economy: an interdisciplinary exploration of the concept and application in a global context. **Journal of Business Ethics**, v. 140, n. 3, p. 369-380, 2017.

NIERO, M. *et al*. Combining Eco-Efficiency and Eco-Effectiveness for Continuous Loop Beverage Packaging Systems: lessons from the Carlsberg Circular Community. **Journal of Industrial Ecology**, v. 21, n. 3, p. 742–753, 2017. Available at: https://doi.org/10.1111/jiec.12554

NIMMEGEERS, P.; BILLEN, P. Quantifying the Separation Complexity of Mixed Plastic Waste Streams with Statistical Entropy: a plastic packaging waste case study in Belgium. **ACS Sustainable Chemistry and Engineering**, v. 9, n. 29, p. 9813–310, 2021. Available at: https://doi.org/10.1021/acssuschemeng.1c02404

NORTH, D. C. Institutions. **Journal of Economic Perspectives**, v. 5, n. 1, p. 97-112, 1991.

NORTH, D. C. **La nueva economía institucional y el desarrollo**. Fundes, 1994.

OLIVEIRA, C. T.; LUNA, M.; CAMPOS, L. Understanding the Brazilian expanded polystyrene supply chain and its reverse logistics towards circular economy. **Journal of Cleaner Production**, v. 235, p. 562–573, 2019. Available at: https://doi.org/10.1016/j.jclepro.2019.06.319

OYELOLA, O.; AJIBOSHIN, I.; OKEWOLE, J. Effective solid waste management in the circular economy: the case study of Lagos State, Nigeria. **Procedia Environmental Science, Engineering and Management**, v. 4, n. 3, p. 143–148, 2017.

PLUSKAL, J. *et al*. Strategic decisions leading to sustainable waste management: separation, sorting and recycling possibilities. **Journal of Cleaner Production**, v. 278, 2021. Available at: https://doi.org/10.1016/j.jclepro.2020.123359

POLYGALOV, S. *et al*. Determination of the composition and properties of PET bottles: evidence of the empirical approach from Perm, Russia. **Waste Management and Research**, v. 39, n. 5, p. 720–730, 2021. Available at: https://doi.org/10.1177/0734242X211011222

PRINCIPATO, L. *et al*. Adopting the circular economy approach on food loss and waste: the case of Italian pasta production. **Resources, Conservation and Recycling**, v. 144, p. 82–89, 2019. Available at: https://doi.org/10.1016/j.resconrec.2019.01.025

ROCHE CERASI, I. *et al*. Household plastic waste habits and attitudes: a pilot study in the city of Valencia. **Waste Management and Research**, v. 39, n. 5, p. 679–689, 2021. Available at: https://doi.org/10.1177/0734242X21996415

ROITHNER, C.; RECHBERGER, H. Implementing the dimension of quality into the conventional quantitative definition of recycling rates. **Waste Management**, v. 105, p. 586–593, 2020. Available at: https://doi.org/10.1016/j.wasman.2020.02.034

RUBIO, S. *et al*. Effectiveness of extended producer responsibility policies implementation: the case of Portuguese and Spanish packaging waste systems. **Journal of Cleaner Production**, v. 210, p. 217–230, 2019. Available at: https://doi.org/10.1016/j.jclepro.2018.10.299

RUTKOWSKI, J. E. Inclusive packaging recycling systems: improving sustainable waste management for a circular economy. **Detritus**, v. 13, n. 314, p. 29–46. 2020. Available at: https://doi.org/10.31025/2611-4135/2020.14037

SCOTT, W. R. Unpacking institutional arguments. In: POWELL, W. W.; DIMAGGIO, P. J. **The new institucionalism in organizational analysis**, p. 164–182, 1991.

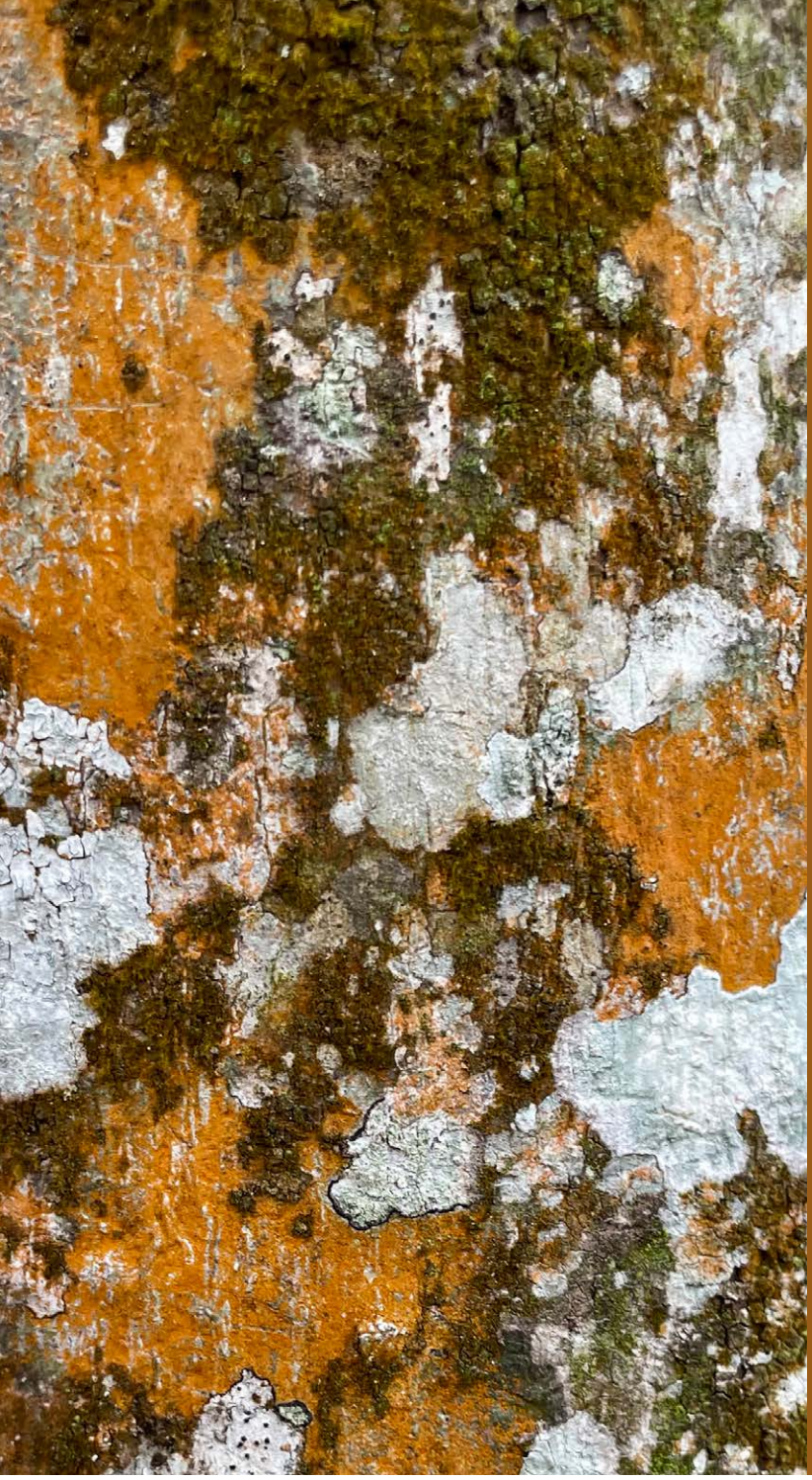
SELINA, M. *et al*. Wet-mechanical processing of a plastic-rich two-dimensional-fraction from mixed wastes for chemical recycling. **Waste Management and Research**, v. 39, n. 5, p. 731–743. Available at: https://doi.org/10.1177/0734242X21996435

SHEHABUDDEEN, N. *et al*. **Management Representations and Approaches**: exploring issues surrounding frameworks. Working Paper for BAM, Cambridge, 2000.

SIMOENS, M. C.; LEIPOLD, S. Trading radical for incremental change: the politics of a circular economy transition in the German packaging sector. **Journal of Environmental Policy and Planning**, v. 23, n. 6, p. 822–836, 2021. Available at: https://doi.org/10.1080/1523908X.2021.1931063

SOMPLÁK, R. *et al*. Implementation of circular economy through the mathematical programming for the complex system evaluation. **Chemical Engineering Transactions**, v. 76, p. 523–528, 2019. Available at: https://doi.org/10.3303/CET1976088

SUDDABY, R. Challenges for institutional theory. **Journal of Management Inquiry**, v. 19, n. 1, p.14–20, 2010. Available at: https://doi.org/10.1177/1056492609347564



In this second issue of 2023, Sustainability in Debate pays tribute in its editorial to Ignacy Sachs (1927-2023), a pioneer in considering the environmental dimension as an inseparable attribute of the pursuit of development.

Subsequently, SiD publishes ten articles in the *Varia* section. Cerezini and Hanai discuss the challenges and guidelines for the integrated management of water in hydrographic basins; Gonçalves *et al*. discuss the relationship between dependence on fossil fuels, oil disasters, and the characterisation of the process of social determination of health in vulnerable territories. Canova *et al*. investigate how climate change has threatened the livelihood and cultural dimensions of peri-urban communities in Central Amazonia, while Fardin *et al*. discuss the identification of extreme rainfall events and disasters triggered by rain in Petrópolis-RJ. Ribeiro highlights the possibilities for energy generation from biomass in the state of Minas Gerais, while Silva *et al*. propose an approach to identify the determining factors for the insertion of mini and microsystems of distributed generation in the agricultural sector. Lobo and Pinto assess the level of road cyclability in Belo Horizonte-MG; Rivaben *et al*. debate agroecological paths for livestock in northern Uruguay; Muñoz-Ávlia and Guerrero discuss the main synergies between the Escazú Agreement and the 2030 Agenda, and Streit *et al*. propose a framework to analyse cases of implementation of the circular economy from the perspective of Institutional Theory.

Nesse segundo número de 2023, Sustainability in Debate, em seu editorial, faz uma homenagem a Ignacy Sachs (1927-2023), pioneiro do pensamento sobre a consideração da variável ambiental como atributo indissociável da busca do desenvolvimento.

Na sequência, SiD publica dez artigos na seção Varia. *Cerezini e Hanai debatem sobre os desafios e diretrizes para a gestão integrada da água em bacias hidrográficas; Gonçalves* et al. *discutem a relação entre a dependência por combustíveis fósseis, desastres com petróleo, e a caracterização do processo da determinação social da saúde nos territórios vulnerabilizados. Canova* et al. *investigam como as mudanças climáticas têm ameaçado a subsistência e as dimensões culturais de comunidades periurbanas na Amazônia Central, enquanto Fardin* et al. *discorrem sobre a identificação de eventos extremos de precipitação e desastres deflagrados por chuvas em Petrópolis-RJ. Ribeiro destaca as possibilidades para a geração de energia a partir de biomassa no estado de Minas Gerais, enquanto Silva* et al. *propõem uma abordagem para identificar os fatores determinantes para a inserção de mini e microssistemas de geração distribuída no setor agrícola. Já Lobo e Pinto avaliam o nível de ciclabilidade viária em Belo Horizonte-MG; Rivaben* et al. *debatem sobre os caminhos agroecológicos para a pecuária no norte do Uruguai; Muñoz-Ávlia e Guerrero discorrem sobre as principais sinergias entre o Acordo de Escazú e a Agenda 2030, ao passo que Streit* et al. *propõem um framework para analisar casos de implantação da economia circular sob a perspectiva da Teoria Institucional.*

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