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Editorial

Science and Brazil's responsibility in the environmental crisis

Carlos Hiroo Saito, Marcel Bursztyn, Gabriela Litre and Patrícia Mesquita,

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It is not typical for a scientific journal to take a stand on circumstantial political aspects. However, given the seriousness of the institutional dismantling process and the disregard towards issues that structurally interfere with sustainability and the future of the environment in Brazil, Sustainability in Debate – SiD expresses, through this editorial, a wake-up call.

The year 2022 seems to reveal a series of weaknesses and civilizational dilemmas on a planetary scale. The Covid-19 pandemic has caused worldwide suffering for two and a half years and is now joined by a new threat to human health: monkeypox. In addition, a new, absurd, large-scale war in Ukraine exposes the fragility of coexistence between neighbours[1]. Moreover, it also exposes the risks inherent to war: human and material losses, nuclear power plants in the firing line, increased food insecurity, massive displacement of populations, and devastation of the natural environment, among others. On top of all this, the worsening of the climate crisis has expressed itself in increasingly intense, frequent and territorial extreme events. In this general context, Brazil is responsible for containing the Amazon biome in its territory, which is essential in regulating the global climate.

Brazil's next elections will be able to democratically choose whether it prefers to follow the anti-environmental path or to resume its strategy of a command-and-control framework, education and practices aimed at a coexistence between the quality of the environment and the pursuit of the material well-being of its population. In the not-too-distant past, the country already played a leading role in the Paris Agreement, actively participating in the construction of goals and consensus and the fight against food insecurity and poverty, with former President Lula winning the World Food Prize in 2011 for its contribution to the fight against world hunger[2].

However, the country has become negatively notable in the international environmental scenario in recent years. Its notoriety grew due to several analysis requests, by the International Criminal Court, of alleged crimes against humanity perpetrated by the current President of the Republic of Brazil on account of his management of the pandemic. However, these initiatives failed in court, given the decision adopted in The Hague. It states that, as a general matter, communications related to Covid-19 would be classified as manifestly outside the jurisdiction of the Court[3]. In recent months, the focus has been on the increase in deforestation in the Amazon, but the debate continued in the International Criminal Court, increasing the repercussion and gravity of this issue.

A new petition delivered in May in The Hague brought evidence of crimes against humanity of the Brazilian president through the destruction of the Amazon and threats to indigenous people. The documents, endorsed by European institutions, come with the support of more than a million signatures from people pressing for action against him[4]. Although the complaint made by the consortium of Deutsche Umwelthilfe, Avaaz, Bourdon & Associates and AllRise was already filed in October 2021, new data came as a basis for the urgent petition to install the preliminary investigation. This movement is driven by the release of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) earlier this year. According to the report, carbon emissions continue to rise, which complicates meeting the targets set out in the Paris Agreement. Therefore, more than ever, mitigation measures are urgent to contain the increase in emissions.

Deforestation and forest fires are part of this context, and the heat wave and the destruction of the forest cover in the Northern Hemisphere only reveal the consequences, which are fed back by climate change. Stopping deforestation and fighting climate change in all parts of the globe becomes imperative to protect our planet as a common good. It is worth noting that, in 2022, the total area affected by forest fires was seven times greater in France and four times greater in Europe as a whole, compared to the average of previous years. This represents a clear manifestation of the seriousness of the problem[5]. The murders of the English journalist Dom Phillips and the Brazilian indigenist Bruno Araújo Pereira in the Amazon in June of this year add to the sad situation to which the Brazilian government is assimilated worldwide, not only as absent in the fight against environmental destruction but also as an inciter of violence and impunity.

Transdisciplinary work is increasingly necessary, in which environmentalists, civil society representatives, jurists and scientists act together. This may maintain legal instruments and administrative practices in coherence with the technical-scientific guidelines of Environmental Sciences to safeguard the principles and objectives of sustainability. The strengthening of actions for planetary sustainability requires, from each country, the fulfilment of closed global agreements. Besides, the maintenance of investments in science, technology and public management is necessary for monitoring and foreseeing the scenarios of environmental degradation and seeking creative and fast solutions to protecting the environment. Capable and committed scientists' actions are crucial. Everyone can join this global network that produces knowledge and great researchers. James Lovelock[6], the renowned scientist behind one of the most fruitful ecological concepts of recent times, left us in July at the age of 103, and he will undoubtedly be missed in this joint effort.

Despite difficulties and setbacks, we are taking essential steps globally towards greater environmental awareness. The international community's engagement in monitoring the Brazilian government's environmental agenda shows global concern and interest strengthening. This movement cannot be condemned by arguing a conflict with national sovereignty. This international awareness also has positive results on another front. A new historic milestone to be highlighted is the decree, in July of this year, by the United Nations General Assembly that affirms a clean, healthy, and sustainable environment is a human right! Indeed, we must transform this act into a new momentum for strengthening efforts for sustainability.

Finally, we must reaffirm that scientific journals such as SiD, with open access, contribute to the expansion of the exchange of knowledge. They play a fundamental role in this process in which the degree of access to knowledge, even among scientists, is a global exclusion or inclusion factor. Science also needs to be democratized and sustainable, giving the entire scientific community access to the global production of knowledge that can contribute to making this world a better place.

The present edition contains eight articles, the first by Fonseca *et al.* focuses on the trajectory of construction and dismantling of forest policies in Brazil, specifically in the Amazon region. Subsequently, Silva and Araújo, in the same biome, investigate the consideration of the Sustainable Development Goals (SDGs) in the Pedagogical Projects of Biology Degree Courses (PPCs) in the Amazon from the State of Para, characterizing the approach of the PPCs on education for sustainability. In the Northeast region, Jales *et al.* discuss the motivations and difficulties in adopting sustainable practices in the supply chains of small and medium-sized companies (SMEs) in the cashew sector in the Ceará State. Furthermore, in Pernambuco, Bernal *et al.* analyse the impact of heat waves on the cardiovascular and respiratory health of the population, discussing how these events from October to March are associated with a higher risk of morbidity and mortality.

At a national level, Gomes *et al.* present an investigation of cetacean observation tourism through a survey of occurrence areas, key species, and norms, aiming to subsidize monitoring and inspection actions. González *et al.*, on a South American scale, call attention to Energy Communities (ECs) and their role in promoting more sustainable, democratic and decentralized electrical systems. Directly

from Ukraine, Sydorova *et al.* analyse the historical context of the establishment of the Ukrainian state, providing a situational assessment of the current economic and environmental risks in Ukraine by investigating anti-crisis "success stories" from other countries. Moreover, in the last article, Italiano *et al.* seek to identify critical aspects and limitations of the creation and modelling process using the Zero Waste approach for its application in the clothing industry, presenting the main limiting aspects and viable alternatives for its implementation in the large-scale clothing manufacturing process.

We hope you enjoy the reading!

NOTES

1| BILYK, O.; KARKOVSKA, V.; KHIM, M. The situation in Ukraine, the consequences of the war for Ukrainian society, science development and sustainability. **Sustainability in Debate**, v. 13, n. 1, p. 12, 2022.

2| Available in: https://www.reuters.com/article/manchetes-politica-lula-wfp-idBRSPE75K0F520110621. Access in: 8 aug. 2022.

3| Available in: https://www.cnnbrasil.com.br/internacional/tribunal-de-haia-diz-que-denuncias-sobre-covid-19-estao-fora-de-sua-jurisdicao/. Access in: 8 aug. 2022.

4| Available in: https://noticias.uol.com.br/colunas/jamil-chade/2022/05/19/com-1-milhao-de-assinaturas-denuncia-em-haia-amplia-acao-contra-bolsonaro.htm. Access in: 8 aug. 2022.

5| Available in: https://www.lemonde.fr/les-decodeurs/article/2022/07/19/rechauffement-climatique-les-feux-de-foret-en-europe-au-plus-haut-a-l-ete-2022_6135383_4355770.html. Access in: 8 aug. 2022.

6| James Lovelock was an outstanding scientist and environmentalist notable for his proposal of the Gaia Hypothesis, according to which Planet Earth functions as a self-regulating system. See for example: https://www.nouvelobs.com/idees/20220728.OBS61432/james-lovelock-est-mort-bruno-latour-nous-avait-raconte-sa-rencontre-avec-le-pere-de-l-hypothese-gaia.html (accessed August 10, 2022).

Editorial

A ciência e a responsabilidade do Brasil na crise ambiental

Carlos Hiroo Saito, Marcel Bursztyn, Gabriela Litre e Patrícia Mesquita

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É inusual um periódico científico se posicionar diante de aspectos políticos conjunturais. Mas, diante da gravidade do processo de desmantelamento institucional e de descaso com questões que interferem estruturalmente na sustentabilidade e no futuro do meio ambiente no Brasil, a *Sustainability in Debate* – SiD adota, neste editorial, uma postura explicitamente de alerta.

Este ano de 2022 está revelando uma série de fragilidades e dilemas civilizatórios em escala planetária. A pandemia da Covid-19, que castiga o planeta há dois anos e meio, junta-se agora a uma nova ameaça à saúde humana: a varíola do macaco (*monkey pox*). Uma nova guerra absurda de grande dimensão, na Ucrânia, expõe a fragilidade da convivência entre povos vizinhos e evidencia também os riscos que são inerentes à guerra: perdas humanas e materiais, centrais nucleares na linha de tiro, aumento da insegurança alimentar, enorme deslocamento de populações, devastação do ambiente natural, entre outros. A esses problemas junta-se o agravamento da crise climática, que tem se expressado em eventos extremos cada vez mais intensos, frequentes e amplos territorialmente. Nesse contexto geral, o Brasil tem uma grande responsabilidade por conter em seu território o bioma Amazônia, que desempenha relevante papel regulador do clima mundial.

O Brasil terá eleições em breve e poderá escolher democraticamente se prefere seguir na via antiambiental ou retomar a sua estratégia de construção de um arcabouço de comando e controle, de educação e de estímulo a práticas voltadas a uma convivência entre a qualidade do meio ambiente e a busca do bem-estar material de sua população. Em um passado não muito distante, o país já ocupou papel de destaque por ocasião do Acordo de Paris, participando ativamente na construção de metas e consensos e no combate à insegurança alimentar e pobreza, tendo o ex-presidente Lula vencido o prêmio *World Food Prize* em 2011, por sua contribuição no combate à fome no mundo .

No entanto, nos anos mais recentes, o país tem se notabilizado no cenário ambiental internacional sob o ponto de vista negativo: a notoriedade ganhou destaque em função de diversas solicitações de análise, pelo Tribunal Penal Internacional, de supostos crimes contra a humanidade perpetrados pelo atual presidente da República do Brasil, por conta da sua gestão da pandemia. Essas iniciativas não prosperaram naquela Corte tendo em vista a decisão adotada em Haia, de que, como questão geral, as comunicações relacionadas à Covid-19 seriam classificadas como manifestamente fora da jurisdição do Tribunal . O foco nos meses mais recentes tem sido no aumento do desmatamento na Amazônia, mas o terreno do debate continuou no Tribunal Penal Internacional, ampliando a repercussão e a gravidade do tema.

Uma nova petição foi entregue no mês de maio em Haia, argumentando indícios de crimes contra a humanidade por parte do presidente brasileiro, devido à destruição da Amazônia e às ameaças aos povos indígenas. Os documentos, endossados por instituições europeias, são acompanhados, desta vez, por mais de um milhão de assinaturas de pessoas, pressionando pela ação contra o presidente do Brasil . Apesar de a denúncia feita pelo consórcio de entidades Deutsche Umwelthilfe, Avaaz, Bourdon & Associates e AllRise já ter sido apresentada em outubro de 2021, novos dados servem de base à

petição de urgência de instalação da investigação preliminar. Essa movimentação vem influenciada pela divulgação do Sexto Relatório de Avaliação do Painel Intergovernamental sobre Mudanças Climáticas (IPCC) no início deste ano. Segundo o relatório, as emissões de carbono continuam aumentando, colocando em risco o cumprimento das metas estabelecidas no Acordo de Paris. Mais do que nunca, as medidas de mitigação se tornam urgentes para conter o aumento de emissões.

O desmatamento e os incêndios florestais se inserem nesse contexto, e a onda de calor e as consequentes destruições da cobertura florestal em chamas no Hemisfério Norte apenas revelam as consequências, que são retroalimentadas pelas mudanças climáticas. Frear o desmatamento e lutar contra as mudanças climáticas, em todos os pontos do globo, tornam-se imperativos para defender o planeta como bem comum. Vale assinalar que, em 2022, a área total atingida por incêndios florestais foi sete vezes maior na França e quatro vezes maior na Europa como um todo, em relação à média dos anos precedentes. Isso representa uma clara manifestação da gravidade do problema . Os assassinatos do jornalista inglês Dom Phillips e do indigenista brasileiro Bruno Araújo Pereira na Amazônia, em junho deste ano, se somam ao triste quadro em que cada vez mais o governo brasileiro é entendido mundialmente não apenas como ausente no combate à destruição ambiental, mas também como incitador da violência e da impunidade dos crimes.

Cada vez mais se faz necessário um trabalho transdisciplinar, em que ambientalistas, representações da sociedade civil, juristas e cientistas ajam conjuntamente para manter os instrumentos legais e as práticas administrativas, em consonância com as diretrizes técnico-científicas das Ciências Ambientais, de modo a salvaguardar os princípios e objetivos da sustentabilidade. O fortalecimento das ações de sustentabilidade planetária requer, de cada país, o cumprimento dos acordos globais assumidos e a manutenção dos investimentos em ciência, tecnologia e gestão pública, capazes de monitorar e antever os cenários de degradação ambiental, buscando soluções criativas e rápidas para a proteção do meio ambiente. A atuação de um corpo de cientistas capazes e comprometidos é crucial. Cada qual pode somar-se a essa rede global produtora de conhecimentos e grandes pesquisadores. James Lovelock , o renomado cientista por trás de um dos conceitos ecológicos mais frutíferos dos últimos tempos, nos deixou em julho aos 103 anos, e certamente fará falta nesse esforço comum.

Mesmo em meio às dificuldades e revezes, damos passos importantes globalmente rumo à maior consciência ambiental. O engajamento da comunidade internacional na vigilância da pauta ambiental do governo brasileiro mostra o fortalecimento da preocupação e do interesse global. Não se pode condenar esse movimento sob argumento de conflito com a soberania nacional. Essa consciência internacional também tem resultados positivos em outra frente: um novo marco histórico a ser destacado, que é a decretação, em julho deste ano, pela Assembleia Geral das Nações Unidas, de que o meio ambiente limpo, saudável e sustentável é um direito humano! Certamente, devemos ser capazes de transformar esse ato em novo impulso para o fortalecimento dos esforços pela sustentabilidade.

E devemos reafirmar, finalmente, que revistas científicas como a *SiD*, de livre acesso ao seu conteúdo, vêm contribuir para a ampliação da troca de saberes, exercendo um papel fundamental nesse processo em que o grau de acesso ao conhecimento, mesmo entre cientistas, é fator de exclusão ou inclusão global. A ciência também precisa ser democratizada e sustentável, abrindo a toda a comunidade científica a produção global do conhecimento que pode contribuir para tornar esse mundo melhor.

A presente edição contém oito artigos, sendo o primeiro, de Fonseca *et al.*, focado na trajetória de construção e desmantelamento das políticas florestais do Brasil, mais especificamente da região amazônica. Na sequência, Silva e Araújo, no mesmo bioma, investigam a consideração dos Objetivos de Desenvolvimento Sustentável (ODS) nos Projetos Pedagógicos de Cursos (PPCs) de licenciatura em biologia da Amazônia paraense, caracterizando a abordagem dos PPCs sobre a educação para a sustentabilidade. Já na Região Nordeste, Jales *et al.* buscam discutir as motivações e dificuldades para a adoção de práticas sustentáveis nas cadeias de suprimentos de pequenas e médias empresas (PMEs) do setor do caju do estado do Ceará. E, em Pernambuco, Bernal *et al.* analisam o impacto de ondas de

calor na saúde cardiovascular e respiratória da população, discutindo como esses eventos nos meses de outubro a março são associados a um maior risco de morbimortalidade.

Em um nível nacional, Gomes *et al.* apresentam uma investigação do turismo de observação de cetáceos, por meio de um levantamento das áreas de ocorrência, espécies-chave e normas, visando subsidiar ações de monitoramento e fiscalização. González *et al.*, em uma escala de América do Sul, chamam atenção para as Comunidades Energéticas (CEs) e o seu papel na promoção de sistemas elétricos mais sustentáveis, democráticos e descentralizados. Diretamente da Ucrânia, Sydorova *et al.* analisam o contexto histórico do estabelecimento do Estado ucraniano, fornecendo uma avaliação situacional do estado atual da economia e dos riscos ambientais na Ucrânia, investigando "histórias de sucesso" anticrise de outros países. E, como último artigo, Italiano *et al.* buscam identificar aspectos críticos e limitações do processo de criação e modelagem usando a abordagem *Zero Waste* para a sua aplicação na indústria do vestuário, apresentando os principais aspectos limitantes e alternativas viáveis para sua implementação no processo produtivo de confecção de vestuário em larga escala.

Desejamos uma ótima leitura!

NOTAS

1| BILYK, O.; KARKOVSKA, V.; KHIM, M. The situation in Ukraine, the consequences of the war for Ukrainian society, science development and sustainability. **Sustainability in Debate**, v. 13, n. 1, p. 12, 2022.

2| Disponível em: https://www.reuters.com/article/manchetes-politica-lula-wfp-idBRSPE75K0F520110621. Acesso em: 8 ago. 2022.

3| Disponível em: https://www.cnnbrasil.com.br/internacional/tribunal-de-haia-diz-que-denuncias-sobre-covid-19-estao-fora-de-sua-jurisdicao/. Acesso em: 8 ago. 2022.

4| Disponível em: https://noticias.uol.com.br/colunas/jamil-chade/2022/05/19/com-1-milhao-de-assinaturas-denuncia-em-haia-amplia-acao-contra-bolsonaro.htm. Acesso em: 8 ago. 2022.

5| Disponível em: https://www.lemonde.fr/les-decodeurs/article/2022/07/19/rechauffement-climatique-les-feux-de-foret-en-europe-au-plus-haut-a-l-ete-2022_6135383_4355770.html. Acesso em: 8 ago. 2022.

6| James Lovelock foi um destacado cientista e ambientalista, que se notabilizou pela proposta da Hipótese Gaia, segundo a qual o Planeta Terra funciona como um sistema que se autorregula. Ver por exemplo: https://www.nouvelobs.com/idees/20220728.OBS61432/james-lovelock-est-mort-bruno-latour-nous-avait-raconte-sa-rencontre-avec-le-pere-de-l-hypothese-gaia.html. Acesso em: 10 ago. 2022.

Deforestation (lack of) control in the Brazilian Amazon: from strengthening to dismantling governmental authority (1999-2020)

(Falta de) controle do desmatamento na Amazônia brasileira: do fortalecimento ao desmantelamento da autoridade governamental (1999-2020)

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ARTICLE – VARIA

ABSTRACT

The deforestation control policies in the Brazilian Amazon have gone backwards in recent years. This article analyses the trajectory of these policies between 1999 and 2020, understanding how and why the State's regulatory capacity has evolved and recently been dismantled. This research is based on a qualitative approach, taking deforestation rates as a reference point and compiling the main forestry regulations at the national level in a timeline that covers the rise and fall of these policies. The conclusions show that between 1999 and 2012, the institutional trajectory followed a capacity-building pattern. However, this pattern went into reverse from 2013 onwards. The period from 2019 has witnessed a process of active dismantling, culminating in a new surge in deforestation and a notable reduction in forest policy density, which has resulted in significant land use changes that may cause irreversible damage to the rainforest and the ecological services it provides.

Keywords: Policy dismantling. Land use policies. Deforestation. Brazilian Amazon.

RESUMO

As políticas de controle do desmatamento na Amazônia brasileira têm recuado nos últimos anos. Este artigo analisa a trajetória dessas políticas entre 1999 e 2020, na busca por compreender como e porque a capacidade regulatória do Estado evoluiu e, recentemente, foi desmantelada. Esta pesquisa se baseia em uma abordagem qualitativa, utilizando as taxas de desmatamento como ponto de referência e compilando as principais regulamentações florestais em nível federal em uma linha do tempo que cobre a ascensão e a queda dessas políticas. As conclusões mostram que, entre 1999 e 2012, a trajetória institucional seguiu um padrão de desenvolvimento de capacidades. No entanto, esse padrão foi invertido a partir de 2013. A partir de 2019, está em curso um processo de desmantelamento ativo, marcado por uma nova onda de desmatamento e por uma notável redução na densidade das políticas florestais.

Palavras-chave: Desmantelamento de políticas. Políticas de uso da terra. Desmatamento. Amazônia brasileira.

1 INTRODUCTION

In democracies – an essential pillar of which is the alternation of power – some axes of public policies are expected to follow nonlinear paths. Thus, according to different political priorities, some regulation mechanisms manifest increases or decreases in their intensity or effectiveness. The case of environmental policies in Brazil is no exception: although the creation and implementation of such policies can be more intense at times, there are also moments of retreat. However, over the past few decades, there has been a clear overall trend towards strengthening governmental regulatory capacity (BURSZTYN; BURSZTYN, 2012). Added to this, it should be noted that there have been very intense setbacks in recent years, which may compromise the path towards evolution.

The process of institutionalising public policies and instruments for forest preservation and control of deforestation in the Brazilian Amazon must be understood within two broader frameworks: the restoration of democracy in Brazil during the 1980s and the emergence of environmental issues on national and international agendas. These milestones prove fundamental when explaining the incremental densification in Brazilian environmental policies.

The growing perception of a global environmental crisis gained traction from the United Nations Conference on Human Environment in 1972 and culminated in the diffusion of the notion of sustainable development in the 1980s (BRUNDTLAND, 1987). At the same time, a process of re-democratisation was underway in Brazil, the democratic regime being restored in 1985, following on from 21 years of military dictatorship. At this time, organised civil society started to mobilise around socio-environmental agendas (AVRITZER, 2017; FRIEDMAN; HOCHSTELLER, 2002; MITTERMEIER *et al.*, 2005), and a new federal constitution was approved in 1988 (FC/88), introducing a healthy environment as a fundamental right of citizenship.

Until the 1980s, the Brazilian environmental policy framework was relatively undeveloped and fragmented. Regulations such as the Forest Code (Law no 4,771/1965), the Water Code (Decree-Law no 7,841/1934) and the National Environment Policy (Law no 6,938/1981) were relatively marginalised within the State structure. The FC/88 brought about an important paradigm shift by transferring environmental law from the sphere of property rights to that of citizenship and collective rights.

The United Nations Conference on Environment and Development (Unced) was held in Rio de Janeiro in 1992, spawning multilateral protocols such as the Framework Convention on Biological Diversity (CBD) and the Framework Convention on Climate Change (UNFCCC). These frameworks boosted and provided parameters for internalising environmental issues within national and subnational frameworks.

A significant number of Brazilian national environmental policies became the responsibility of the Ministry of the Environment (ME), created in 1992. Within its structure, this Ministry incorporated the Brazilian Institute for the Environment and Renewable Resources (Ibama), responsible for enforcing federal regulations on deforestation.

A period of consolidation followed concerning environmental policies and instruments. The National Environment Fund (NEF) was created in 1996; the National Water Resources Policy was established in 1997 (Law no. 9,433/97); the Law of Environmental Crimes was enacted in 1998 (Law no. 9,605/1998); and in 2000, the National System of Conservation Units (known by the Brazilian acronym Snuc[1] Law no. 9,985/2000) was established.

The Amazon has always held a prominent position on the Brazilian environmental agenda. In addition to its socio-ecological value, recognised for hosting most of the Brazilian and a large part of the world's biodiversity, the Amazon Forest encompasses approximately 40% of the national territory and retains an essential cultural heritage in the form of diverse indigenous and local peoples. Furthermore, in the early 1990s, although it had a relatively high degree of integrity (primary forests covered 90% of the territory), it was under strong pressure from agricultural frontier expansion (TERRABRASILIS/INPE, 2020). Thus, protecting and conserving the Amazon has represented a sensitive and central topic in the process of institutionalising the environmental agenda in Brazil during the post-democratisation process and poses a political challenge that requires the integration of several sectoral policies. Therefore, understanding the evolution of forest policy in relation to the Amazon is also, to a certain extent, to understand the evolution of Brazilian environmental policy.

This article analyses the institutional trajectory of national policies and instruments on land use change, taking as a key indicator the rates of deforestation in the Amazon between 1999 and 2020, a period covering six presidential terms: the second term of Fernando Henrique Cardoso (1999-2002); Luís Inácio Lula da Silva's first (2003-2006) and second terms (2007-2010); Dilma Rousseff's first (2011-2014) and second (2014-2016) terms; and Michel Temer (2016-2018) and Jair Bolsonaro's (2019-2020) terms. The aim here is to understand how governmental changes in different presidential terms have influenced the State's regulatory capacity and to reflect on the trend of dismantling in recent years.

The article is divided into five sections, this Introduction comprising the first. The second section addresses the theoretical framework. The third presents the methodology. The fourth presents the results of the analysis of the annual deforestation rates and a timeline composed of the main institutional-change milestones while also discussing those data. The final considerations summarise the main research findings.

2 CAPACITY BUILDING, PATH DEPENDENCE AND POLICY DISMANTLING

To understand the process of institutional capacity building, it is essential to acknowledge the need to "respect the historicity inherent in socio-political structures" (SKOCPOL *et al.*, 1985, p. 28). North (1990, p. 99) perceived the concept of path dependence as "a way to narrow the choice set and link decision-making conceptually through time". Policies are strongly impacted by their past trajectory, which shapes their future (PIERSON, 2000). Limited by the broader context, change and transformation tend to be incremental, gradual and low in intensity.

Path dependence is formed by historical sequences in which certain events lead to institutional patterns or generate chains of actions and reactions that influence the trajectory of politics through institutional inertia (MAHONEY, 2000). The beginning of the trajectory is unpredictable, as there are several possible decision-making paths. However, once the decision is made, the path to be followed tends to be conditioned by the previously made decision (PIERSON, 2000).

The existence of complex normative frameworks, interrelation of diverse policies and interplay of forces between stakeholders in multiple arenas make sudden changes in public policies rare. Creating new policies that do not represent an evolution compatible with the previous institutional trajectory becomes challenging. It is also difficult to dismantle policies since lock-in mechanisms (MAHONEY, 2000) delimit not only the possible paths of change but also represent the high costs related to dismantling. Acting to dismantle a policy tends to generate strong reactions from the actors who support and benefit from the policy, that is, from its advocacy coalition (SABATIER; WEIBLE, 2007).

The idea of path dependence has been revised, emphasising some limitations. Among the criticisms is that path dependence only explains institutional stability and not the changes perceived by its defenders as exceptions to the rule (DOBROWOLSKY; SAINT-MARTIN, 2005; GREENER 2005; KAY, 2005).

After 2008, due to European austerity policies, cases of dismantling gained ground in academic debate (BAUER *et al.*, 2012). This occurred for two main reasons. Firstly, austerity led to dismantling policies it had taken decades to build and expand. In some cases, the dismantling process was intense, generating strong societal reactions (JORDAN *et al.*, 2013). In other cases, the process faced few and only mild adverse reactions (GÜRTLER *et al.*, 2019; SABOURIN *et al.*, 2020). Secondly, the post-crisis context was marked by the global rise of far-right populist groups with agendas explicitly committed to the destruction of certain policies, including those related to environmental sustainability and climate change (GÜRTLER *et al.*, 2019; HUBER *et al.*, 2020; KROLL; ZIPPERER, 2020; KULIN *et al.*, 2021; LEVITSKY; ZIBLATT, 2018; LOCKWOOD, 2018; MOUNK, 2018).

Bauer and Knill (2012, p. 6) defined the dismantling of public policies as:

> a change of a direct, indirect, hidden or symbolic nature that either diminishes the number of policies in a particular area, reduces the number of policy instruments used and/or lowers their intensity. It can involve changes to these core elements of policy and/or it can be achieved by manipulating the capacities to implement and supervise them.

Therefore, the focus is on the preferences of political actors, who put different dismantling strategies into practice that have different impacts on policies. This can lead to policy weakening and/or destruction (BAUER *et al.*, 2012). While path-dependence scholars tend to emphasise the institutional structure, the literature on dismantling places a greater focus on agency: politicians are seen as rational actors whose actions in relation to dismantling tend to be guided by a cost-benefit assessment, the aim being to maximise support among the electorate or specific interest groups (lobbies).

Politicians may either want to be directly related to dismantling, receiving "credit" for the destruction, or to avoid its political costs by keeping it hidden, transferring responsibility to other actors and government levels, or wrapping it up in appealing narratives such as efficiency. In most policies, including social ones, politicians tend to avoid exposing themselves as opponents and bear the associated costs. However, some actors may expect benefits from openly dismantling them in areas marked by strong ideological content, such as environmental policies (Table 1).

Table 1 | Dismantling environmental and social policies: main differences.

Dismantling features	*Environmental policies*	*Social policies*
Behaviour of politicians	They may prefer to be openly linked to the dismantling, receiving the "credit".	The tendency is to avoid the costs, adopting more “hidden” strategies.
Costs and benefits	Diffuse benefits for society and costs concentrated in specific sectors and social groups (generally well organised and endowed with economic power).	Benefits concentrated in certain social groups (target audience). Diffuse costs for society.

Behaviour of advocacy coalitions	More fluid coalitions; higher mobilisation and reaction costs. Reaction to dismantling tends to be lower.	Cohesive coalitions; lower costs for organisation and mobilisation. Reaction to dismantling tends to be greater.
Relative difficulty in dismantling	Easier dismantling.	Difficult dismantling.

Source: Authors' work, based on Bauer et al. (2012); Bauer and Knill (2012); Gürtler et al. (2019); Jordan et al. (2013) and Sabourin et al. (2020).

Dismantling strategies work in two ways: in terms of density and intensity (BAUER *et al.*, 2012; JORDAN *et al.*, 2013). A decrease in density means a reduction in the number of policies and/or regulations. Density reduction is the disappearance of one or more structures, instruments or functions relevant to the policy's orientation, implementation and/or supervision.

A reduction in intensity means a decrease in the level of advantages or restrictions of a given policy. In social policies, this can be the value of a social benefit or its target audience. In environmental policies, the intensity can, for example, be limits on atmospheric emissions or the percentage of the area destined for environmental preservation on rural properties. The reduction of resources allocated for implementation and impacts on the operational capacity of monitoring and evaluation are also part of the dimensions present in intensity-reduction dismantling.

3 METHODOLOGICAL PROCEDURES

The methodology adopted has a qualitative approach. In addition to the specialised literature, this article uses annual deforestation rates for the period 2000[2]-2020 provided by the National Institute for Space Research (Inpe). We present a timeline that shows the main decisions, policy interventions and key moments in the creation, modification and extinction of federal laws and ordinances; resolutions of the National Environment Council (Conama); and environmental management instruments that come under the responsibility of the ME and other FG agencies directly related to deforestation policies from 1999 to 2020.

We used official Brazilian government websites (executive, legislative and judicial branches) to identify the main institutional changes in the federal forest policy. Additionally, we reviewed newspaper reports and organised civil society publications to help to identify the directions of such changes.

These data are analysed from an institutionalist perspective (FIORETOS *et al.*, 2016), emphasising concepts such as policy dismantling (BAUER *et al.*, 2012; BAUER; KNILL, 2012; JORDAN *et al.*, 2013). Therefore, this article mainly focuses on dismantling by reducing institutional density. Primarily, this entails analysing the creation, transformation and extinction of regulations, policies and management instruments. However, as a complement to this, in describing institutional changes, we have emphasised some changes in policy intensity.

The FG's actions have been divided into categories (see Table 2): measures that implied an increase in institutional density (green marker); measures that led to dilution[3] of the institutional framework (red marker); and "ambiguous" measures that represent flexibilisation or a reduction in scope within the institutional framework that stopped short of actual elimination, or, alternatively, that simultaneously promoted an increase and a reduction in institutional density (orange marker).

The next step consisted of arranging the measures chronologically along a timeline with the deforestation data on the Brazilian Amazon between 2000 and 2020 (see Figure 1). After this step, we proceed to a qualitative analysis of the institutional changes' contexts. This qualitative analysis allows us to develop a typology of three distinct moments in the historical-political trajectory of federal forest policy: 1999-2012 (institutionalisation), 2013-2018 (soft dismantling) and 2019-2020 (severe dismantling).

It is worth noting that although the qualitative methodology used here does not allow for a causal analysis of measures and deforestation rates, it does provide a chronological alignment of how these policies evolved and deforestation data, which has, in turn, allowed us to pose hypotheses to be explored in future research.

4 RESULTS AND DISCUSSION

This section analyses the capacity building and dismantling of national policies and practices related to land use change and deforestation in the Brazilian Amazon. Figure 1 and table 2 show a predominance of measures to increase institutional density between 1999 and 2012. Then, there followed an "ambiguous" period in which, on the one hand, the institutional design of federal environmental policies remained relatively stable and, on the other, a reversal of the trend (2013-2018) was noted. Finally, 2019-2020 marked a severe and active dismantling of environmental policies, with an accumulation of measures directly and openly related to reducing institutional density.

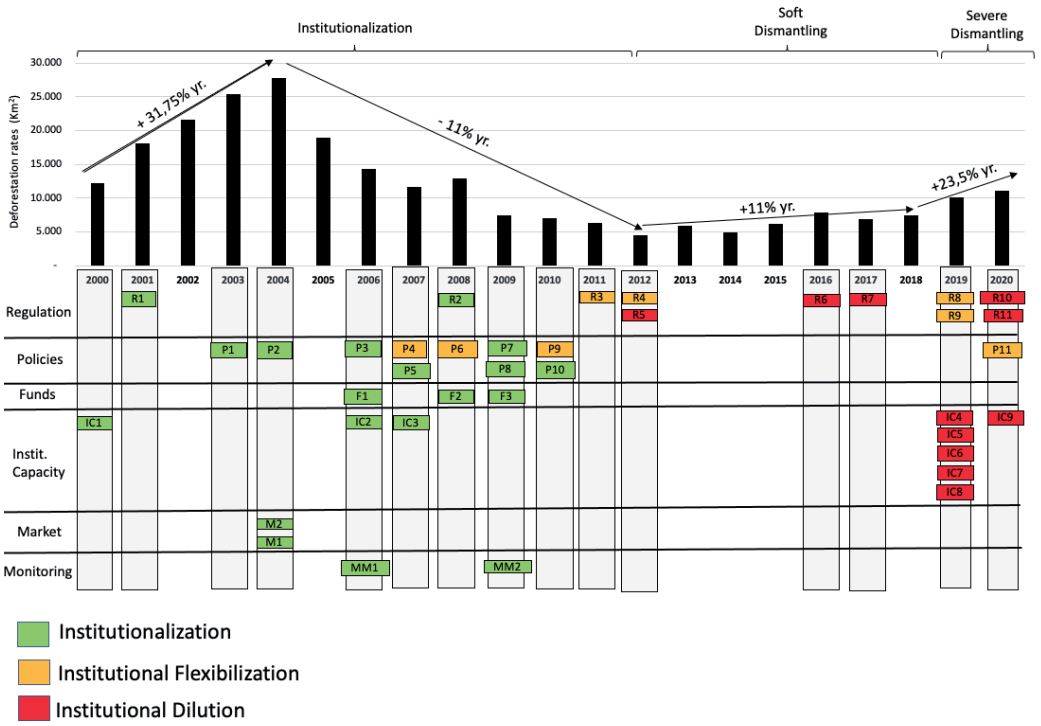

Figure 1 | Institutionalisation of the environmental agenda for the Amazon between 2000 and 2020 in relation to the evolution of deforestation rates.

Source: Authors' work; data from PRODES/INPE (2020).

Table 2 | Governmental measures, a brief description of their content and an assessment of their relevance in institutional density. Green: institutionalisation measure; Orange: soft dismantling measure; Red: severe dismantling measure. Type of Measure – IC: Institutional Capacity; R: Regulation; P: Policies; M: Market; F: Funds; MM: Monitoring

Measure		*Impact*
Snuc	IC1	Established the framework for the management of National Conservation Units in Brazil.
Forest Code adjustment	R1	Among other adjustments, it increased the obligatory preservation area on rural properties from 50% to 80% in the Amazon.
Arpa	P1	Created to support the expansion of Snuc.
PPCDAm	P2	Provided a framework to articulate and integrate information, institutions and actions in controlling deforestation.
Prodes incorporated in PPCDAm	M1	Provided annual data on the area deforested and deforestation rates.
Deter	M2	Provides real-time data on deforestation. In the PPCDAm, it is used as information for the short-term planning of surveillance operations.
National Forestry Development Fund	F1	Designed to promote sustainable forestry activities and technological innovation.
Transfer of the SFB to the ME	IC2	The SFB coordinates the concession and exploitation of national forests. Within the ME, the SFB became more integrated to combat and control deforestation.
General Law of Public Forests	P3	Established the legal framework and instruments for public forest sustainable management.
Soy Moratorium	MM1	Pact between civil society and soy production chain to ban the purchase of soy produced in illegally deforested areas.
Growth Acceleration Program (PAC)	P4	National infrastructure investment program. In the Amazon, it financed the construction of large hydroelectric dams and road developments that historically acted as deforestation drivers.
ICMBio	IC3	ME agency created to implement the Brazilian CUs policy.
List of priority municipalities for combating deforestation	P5	Planning instrument to focus combat and control mechanisms in a short list of municipalities covering the majority of deforested areas.
Regulatory change on sanctions that an environmental agent can undertake	R2	Allowed environmental inspectors to disable or destroy equipment used in illegal deforestation in hard-to-reach forest areas.
AF	F2	Finance sustainable actions in the Amazon rainforest.
PAS	P6	Established guidelines and proposed the drafting of sectorial plans for sustainable development in the Brazilian Amazon. Has had ambiguous impacts in considering the integration of environmental issues from a broader developmentalist paradigm.
PNMC	P7	Establishes political instruments and guidelines for climate adaptation and mitigation policies.
CF	F3	Supports projects to reduce greenhouse gas emissions and climate adaptation.
1st National Climate Change Plan	P8	Presented during COP 14 in Poland, among its goals was an ambitious reduction in Amazon deforestation rates.
Beef Industry Conduct Adjustment	MM2	Pact between producers, beef industry and the FG to block the sale of cattle meat from embargoed lands or from areas engaged in illegal environmental acts.
MacroZEE	P9	Planning instrument regulating land use in the Amazon.
1st sectoral mitigation plans	P10	Establishes guidelines and mitigation actions for different sectors. The PPCDAm was included in the national plan.
Law reformulating the cooperation framework among entities of the Brazilian federation	R3	Restricted the inspection powers of environmental agencies and created loopholes to disrespect the pact between the federal entities regarding the competencies of the environmental licensing of infrastructure projects, centralising competencies at the national level; potential negative consequences for deforestation.

Measure		Impact
FC-2012	R4	Eased environmental requirements and sanctions for illegal deforestation committed prior to July 2008. Also established the CAR and PRA as instruments for environmental conformity of rural properties.
Reduction of limits for 7 CUs	R5	Reduction of 86 thousand hectares of CU areas for implementing a hydroelectric dam and roads.
Part of a CU to move to a more flexible land use category	R6	A part of Jamanxim national forest was converted into an Environmental Protection Area (EPA), a less restricted CU type.
Part of a CU moved to a more flexible land use category	R7	Another part of Jamanxim national forest was converted into an EPA. This conversion was carried out to allow the construction of a section of railway.
Change in the administrative process for environmental fines	R8	The collection of fines imposed by the Ibama and ICMBio was suspended until a conciliation hearing. In practice, this measure limited the application of fines related to illegal deforestation.
Termination of the deadline for registering properties in the CAR	R9	Eliminated the pressure on producers to regularise their environmental situation, reinforcing the perception of tolerance and flexibility in the environmental legislation enforcement.
Transfer of SFB from the ME to the MAPA	IC4	The SFB is responsible for managing the CAR. The agriculture lobby had long demanded the transfer of the SFB from the ME to the MAPA.
SCCF	IC5	The SCCF and its Department of Forests and Combating Deforestation, responsible for the implementation of the PPCDAm, has been extinguished.
Elimination of the PPCDAm Executive Committee and Inter-ministerial Working Group	IC6	Even though the PPCDAm still formally exists, the SCCF and its Executive Committee's elimination was annulled.
Reformulation of the Conama	IC7	Changed the composition of the Council and the mechanisms for choosing the subnational governments and civil society representatives.
Elimination of the Foco	IC8	Paralysed the AF's work and led the main donors to cancel their contributions.
Exclusion of Civil Society from FNMA debates	IC9	The FNMA's Deliberative Council decides on project selection and allocations of the fund's resources.
Revocation of Conama Resolutions 302/2002 and 303/2002	R10	The changes in Resolution 302/2002 eliminated the obligation to delimit a 100m strip as a Permanent Protection area around artificial reservoirs in rural areas. Resolution 303/2002 regulated restricted deforestation in mangroves, sandbanks and dunes.
Deregulation of timber export control (NI-7)	R11	Ibama directly controlled the origin of timber before exportation. Deregulation suspended this power.
National Plan for the Control of Illegal Deforestation and Recovery of Native Vegetation (2020-2023)	P11	The Plan was a response from Bolsonaro's government to the PPCDAm, whose governance structure was dismantled. It was formulated without the participation of civil society and does not present goals, targets or actions. Furthermore, no information is available on the source of funds or the institutional coordination responsible for its implementation.

Source: Authors' work.

The following three subsections present a discussion based on the data collected. Each subsection addresses a specific period in the trajectory of federal environmental policies over the past 20 years.

4.1 1999-2012: INSTITUTIONALISATION AND CONSOLIDATION OF ENVIRONMENTAL POLICIES

The high rates of deforestation between 1999 and 2004 were related to two factors: an increase in international demand for commodities (soy and beef) and the devaluation of the Brazilian currency (ALBERNAZ, 2006; BARBER *et al.*, 2014; BARONA *et al.*, 2010; LAURANCE, 2007; LAURANCE *et al.*, 2011; MORTON *et al.*, 2006). Furthermore, transitions between governments with different political orientations, usually marked by uncertainty and the expectation of changes in administration, also contributed to deforestation (RODRIGUES FILHO *et al.*, 2015).

In the late 1990s and early 2000s, the aforementioned factors combined within a context of low institutional capacity for forest conservation and land use policy in the Brazilian Amazon, leading to an institutionalisation process marked by capacity building and institutional densification. A set of actions and measures related to the creation and implementation of public policies was identified for the period comprising 1999 to 2012[4]. These actions were characterised by an incremental advance and relatively constant institutional consolidation, resulting in a significant reduction in annual deforestation rates in subsequent years.

Figure 1 shows that early institutional development was focused on regulatory measures, mainly on creating and implementing policies, plans and programs. This process was associated with the mobilisation of civil society and its participation in policy-making and activism by civil servants in governmental institutions (ABERS; OLIVEIRA, 2015). Between 2003-2008, the ME was headed by Marina Silva, who had historically played a leadership role in the socio-environmental agenda. During her term, a high percentage of the ME's high-ranking positions were occupied by NGO activists involved with indigenous and local populations and forest conservation movements.

Concerning regulatory acts, the period after 1998 saw the emergence of acts aimed at combating and controlling deforestation. An important milestone in the early days of this policy was the enactment of the Environmental Crimes Law[5] Which established the legal provision that made deforestation a crime. In 2001, the Forest Code was modified, expanding the mandatory area for the preservation of native forests from 50% to 80% and the areas of the *Cerrado* (a savanna-type ecosystem) within rural properties in the Amazon territory from 20% to 30%[6]. These measures created a more restrictive environment for deforestation and established legal bases for surveillance to counter illegal activity.

In the field of conservation, scientific evidence points to the efficiency of protected areas – such as conservation units (CUs) and indigenous lands (ILs) – as barriers to the expansion of deforestation, particularly those located close to roads and large urban centres (PLAFF *et al.*, 2015). In 2000, the Snuc[7] established guidelines and instruments for the creation and management of protected areas in Brazil. Furthermore, the Amazon Protected Areas program (Arpa) was launched in 2003 to expand and strengthen the Snuc. Arpa provided resources and improved the management of protected areas (ARAÚJO, 2010). CUs have therefore undergone substantial expansion in the Amazon since 2006 (PNUC, 2020), representing an expression of the institutionalisation of protected area policies.

Another indicator of the increase in the institutional capacity building was the approval of the General Law of Public Forests in 2006[8], which (i) regulated the management and exploitation of public forests, (ii) transferred administration of the Brazilian Forest Service (SFB) to the ME, and (iii) created the National Fund for Forestry Development. This new legislation was particularly important, as over 600,000 km^2 of Amazon land was classified as public forest in 2006 (AZEVEDO-RAMOS *et al.*, 2016). In 2007, the Chico Mendes Institute for Biodiversity Conservation (ICMBio) was created to propose, implement, manage, protect, monitor and inspect CUs[9].

The escalation of deforestation rates and the still incipient regulation framework inspired the formulation of the Amazon Deforestation Prevention and Control Plan (PPCDAm), which was launched in 2004 (BRAZIL, 2004). Actions implemented under the PPCDAm received the support of the Amazon Deforestation Monitoring Program (Prodes), a system aiming at monitoring deforestation using satellite images and internationally acknowledged for its technical robustness (KINTISH, 2007; MARQUES, 2019). The Prodes, under the coordination of Inpe, produces data with good spatial resolution annually, providing key information for planning the PPCDAm.

However, efficient control also requires real-time data on deforestation rates, which can guide timely enforcement actions. Thus, at the request of the ME, in 2004, Inpe developed the System for Deforestation Detection in Real Time (Deter), which produces daily deforestation alerts and identifies pressure spots in the forest (MARQUES, 2019). The transparency of Prodes and Deter data is guaranteed

by the open access of its bases and methodologies (INPE, 2019). Since 2007, the FG has used these two systems to refine the focus of its action by establishing a list of priority municipalities for PPCDAm actions. The initial list, which included 39 municipalities, has been updated under deforestation rates.

Furthermore, new regulation adjustments have increased the command-and-control framework. A 2008 Federal Decree regulated the Environmental Crimes Law, expanding the scope of sanctions that environmental authorities can apply in cases of violations[10]. Among these, it is worth noting the possibility of destroying equipment used during the violation (such as tractors and trucks) when it is impossible to arrest the perpetrators.

Other mechanisms that do not fall within the scope of governmental policies are important in explaining institutional capacity building, such as the soy moratorium, declared in 2006, by means of which, under pressure from the national and international consumer market, the rural production chain blocked the purchase of soybeans from illegally deforested areas. The impact of the moratorium was immediate. Prior to its signing, 30% of soy planting in the Amazon was directly carried out in newly deforested areas, while this figure dropped to 1% afterwards (GIBBS *et al.*, 2015). The restrictions imposed by the moratorium were partially circumvented through fraud regarding the origins of illegal soy (which was sold as originating from legal areas) and associated with deforestation leakage to less protected areas, such as Cerrado areas or, indirectly, by displacing pasture towards the deforestation frontier (CARVALHO *et al.*, 2019).

The increase in institutional density resulting from the aforementioned actions, instruments and policies explains much of the consistent and significant drop in deforestation rates since 2005, framing land use change decisions by local actors (ARIMA *et al.*, 2014; CABRAL *et al.*, 2018; GIBBS, 2015; MAIA *et al.*, 2011; MELLO; ARTAXO, 2017). Even with the boost of a new cycle of the agricultural commodities market starting in 2006, forest-loss rates have remained relatively stable.

Some management instruments were enacted towards the end of 1999-2012. Among these, it is worth mentioning the creation of the Amazon Fund – AF[11], the resources for which played an important role in bringing the PPCDAm into operation. Furthermore, the Plan for a Sustainable Amazon (PAS) was launched in 2008, followed shortly afterwards by Amazon Ecological-Economic Macrozoning (MacroZEE), which was introduced in 2010. Both sought to reconcile forest protection and deforestation control with land use change actions as a result of pressures from the agricultural sector, in reaction to environmental policy enforcement.

This period also coincided with an impulse to institutionalise the climate agenda within the political and legal frameworks through the National Policy on Climate Change (PNMC)[12]. Brazilian foreign policy strategy was to present the country as a leader in global climate change governance. In order to legitimise such a goal, Brazil set an ambitious voluntary target to mitigate its emissions by reducing deforestation[13], its main source of greenhouse gas emissions (AMORIM, 2010; BRAZIL, 2010).

In summary, the period between 1999 and 2012 was characterised by a relatively constant institutional capacity-building framework. Several of these measures and regulations were interconnected, in line with the characteristics of path dependence. The FG's orientation was favourable to the consolidation of forest policies during the presidential terms of both FHC and Lula. At the same time, opposite advocacy coalitions were not very organised or active during this period.

4.2 2013-2018: INSTITUTIONAL STABILITY AND REVERSAL OF THE DENSIFICATION TREND

The process of institutional capacity building regarding the forest protection agenda has provoked resistance inside and outside the FG, with the strengthening of advocacy coalitions opposed to forest

policies. Among the signs of a resurgence in anti-deforestation-control lobbies was Marina Silva's departure from the ME in 2008 due to disagreements between Silva and other ministers (especially Dilma Rousseff, former Minister-Chief of Staff) during the PAS preparation process. Marina Silva had been in charge of the ME since the beginning of Lula's first term (2003-2006), and her agenda was beginning to clash with those of other government sectors pushing for a *developmentalist approach*[14].

The economic sectors involved in deforestation reacted strongly. On the one hand, they adapted to market pressures through pacts and environmental commitments such as the soy moratorium and the signing of the "Term of adjustment"[15] for meat companies (CARVALHO *et al.*, 2019). On the other hand, they organised among themselves politically to delay, soften or even reverse Brazil's institutional framework related to environmental protection.

During Dilma Rousseff's terms, the anti-environmental agenda in the National Congress was strengthened by an organised coalition – the farmers' parliamentary front. In 2010 this group managed to instigate a resumption of the debate on the Forest Code. President Rousseff was a former minister of energy and mining; she often held positions contrary to those of former minister Marina Silva and was sometimes seen as anti-environmental.

Along with the strengthening of the farmers' parliamentary front, in 2012, the ideological shift within the FG culminated in the approval of a new and milder instrument: the FC-2012[16], which had less institutional density than the previous forest code. The FC-2012 adopted a more lenient framework regarding the illegal deforestation crimes committed prior to 2008, promoting regulatory changes such as the establishment of more flexible criteria in defining permanent preservation areas (PPAs) and legal reserves (LRs) on rural properties. It also changed the articles that determined parameters for the restoration of environmental liabilities[17] (RORIZ *et al.*, 2017).

In addition, FC-2012 also introduced two important instruments related to forest management on rural properties: the Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA). The former was a georeferenced statement of the property's environmental status, identifying its assets and liabilities. If effectively implemented, the result generates an important land use database for monitoring changes in the Amazon, with a positive impact on environmental policy enforcement (SOARES FILHO *et al.*, 2014). The latter was a "Term of adjustment", in which farmers commit to restoring environmental liability when identified by the CAR.

Expectations regarding the role played by the CAR and PRA as instruments for controlling deforestation have been affected by their slow implementation process. Initially, the deadline for registration was set in 2014, but successive rescheduling followed, reinforcing the perception by local actors that legislation could always be manipulated (RORIZ *et al.*, 2017). Furthermore, adhesion to the CAR alone did not prevent illegal deforestation in many areas, nor did it guarantee that PRAs were carried out (AZEVEDO *et al.*, 2017; MOUTINHO *et al.*, 2016).

FC-2012 represented a milestone on the trajectory of policies to combat and control deforestation in the Amazon, which had previously been predominantly marked by capacity building and density increases. In contrast, the period following the FC-2012 saw the coexistence of measures that continued the institutionalisation of deforestation-control policies alongside actions, regulations and changes in the implementation of management instruments that made land use policies more flexible. This led to deforestation rates once more increasing from 2013 onwards (SOARES FILHO *et al.*, 2014).

In addition, this period also accelerated the institutionalisation and consolidation of the Brazilian climate agenda, which in many respects reinforced measures to control deforestation and protect the Amazon biome, especially in mitigation actions. One example was the Climate Fund (CF), a financial mechanism for mitigation and adaptation actions. Then there were other sectoral mitigation plans and the implementation of the Low Carbon Agriculture plan, which was aimed at forest protection, either

through the direct protection of forest areas or by indirectly reducing the pressure on new areas for the intensification of agriculture on the agricultural frontier (LA ROVERE *et al.*, 2013; TABOULCHANAS *et al.*, 2016).

4.3 2019-2020: ACTIVE DISMANTLING OF POLICIES TO COMBAT DEFORESTATION

Policies designed to combat and control deforestation encountered a major setback during Jair Bolsonaro's administration, which started in January 2019 (FERRANTE; FEARNSIDE, 2019; 2020). The trend towards reducing policy density identified in the previous period deepened during Bolsonaro's term. Figure 1 shows that this dismantling was aimed at regulatory aspects and institutional capacity to implement the previously created instruments.

The new political authorities responsible for implementing environmental policies no longer hide their alignment with the anti-environmental political lobby. Rather, they have sought to associate their image with the dismantling process, a typical characteristic of active dismantling (BAUER; KNILL, 2012).

In a highly ideological political environment, the FG has justified the extinction of and changes to instruments and policies as necessary for expanding national sovereignty, increasing individual freedoms and encouraging production and economic growth. Additionally, scientific denialism (BURSZTYN *et al.*, 2021) has served as an argument for dismantling the State's capacity and inaction (MCCONNELL; HART, 2019). For instance, the following have all been denied by the FG: the reality of deforestation and forest fires; evidence from satellite data (ARAÚJO; VIEIRA, 2019); scientists' warnings; and climate change evidence and prospects (COUTINHO *et al.*, 2020; PEREZ *et al.*, 2020; SANTOS *et al.*, 2020). In the meantime, international commitments have also been disregarded.

During the transition of government in 2018, the president-elect announced the possible elimination of the ME, generating national and international reactions. Finally, the ME was maintained but with fewer responsibilities. On the first day of government, the SFB was transferred from the ME to the Ministry of Agriculture, Livestock and Supply (Mapa)[18] Accentuating the "productive" bias of forest policies.

Following the decision to maintain the ME, Ricardo Salles[19] was appointed to head it, a lawyer with links to the agribusiness sectors most at conflict with environmental regulations. Minister Salles made it clear that he considered environmental issues in Brazil to be excessively regulated, which in turn generated losses for productive activities. In addition to defending the interests of beef and soy exporters to the detriment of environmental protection, Salles was also a spokesperson for groups historically at odds with actions implemented by the ME: loggers, illegal miners and invaders of indigenous lands (CAPELARI *et al.*, 2020).

At an inter-ministerial meeting held in April 2020, Salles said it was important to take advantage of the fact that public attention was focused on the Covid-19 pandemic to move forward with deregulation and the repeal of environmental standards. Vale *et al.* (2021) analysed measures to dismantle environmental policies beyond those related to forest policies and the Amazon biome during the pandemic. The authors have identified 57 legislative acts that have changed environmental policies since the beginning of the Bolsonaro government's term, almost half of these being drafted after the onset of the pandemic in Brazil in March 2020.

Soon after taking office, Salles eliminated the Secretariat for Climate Change and Forests, or SCCF, and the Department of Forests and Combating Deforestation, which was responsible for implementation of the PPCDAm[20]. As well as losing its leadership and coordination structures, the PPCDAm also lost its governance structure, with the extinction of its Executive Committee and the Permanent Inter-ministerial Working Group[21]. It was not until July 2020 that the FG presented the National Plan for the Control of Illegal Deforestation and Recovery of Native Vegetation (2020-2023), which includes

actions related to deforestation (BRAZIL, 2020). In contrast to the PPCDAm, this plan was created without the participation of civil society and consolidated in a document that did not stipulate either objectives, targets or actions. Moreover, no information is available regarding the source of funds or those responsible for their allocation.

With regard to illegal deforestation surveillance, the government's actions have been marked by measures to reduce intensity, such as cutting resources for inspection, replacing civil servants in management positions with appointees committed to anti-environmental lobbies, and issuing informal guidelines to loosen law enforcement. From the point of view of density, setbacks can also be found in relation to regulation. One such example is Normative Instruction n. 7 (NI-7), enacted by the president of Ibama in February 2020[22]. Based on the justification of "fewer civil servants" and "great procedural and supervisory demand", it was decided that Ibama would no longer be responsible for directly inspecting the shipment of timber cargo destined for exportation at national ports. In practice, the NI-7 represents a loosening of inspection, which benefits the international illegal timber trade. In addition, Decree 9,760/2019[23] suspended the collection of fines imposed by Ibama and ICMBio until a conciliation hearing was held, a measure that limited the application of fines related to illegal deforestation. Furthermore, the FG removed the deadline for registering properties in the CAR[24], eliminating the pressure on producers to regularise their situation.

Density reduction is also witnessed in the suspension of international transfers received by the AF. Since the beginning of Bolsonaro's term, the AF has not supported new projects, even with its available resources. After Minister Salles questioned the resource-management model and defended its reformulation, the financing countries – notably Norway and Germany – suspended their donations to the AF. The formal justification for this suspension was the rupture of the fund's governance structure, emphasising the elimination of the Fund's Orientation Committee – Foco.

The Foco was eliminated on April 11, 2019[25] by means of Decree No. 9,759, which dismantled the National Policy for Social Participation. This decree got rid of several federal councils and committees. Its initial scope had been to eliminate all councils, adopting the argument that only those which could prove their worth would be recreated in the future[26]. Bolsonaro's government also excluded civil society representation from the deliberative council of the National Environment Fund (FNMA)[27].

Other councils, such as Conama and the National Council for Water Resources (CNRH), provided for by law, were maintained. However, following the limitations enforced by Decree 9,759/2019, Bolsonaro's government used another strategy to weaken legally instituted councils: internal restructuring, characterised by attempts to implement government control, reducing member numbers and the co-option of civil society representatives. This strategy relies on changing the rules for how councils operate, such as reformulating their duties, composition and internal regulations (AVELINO *et al.*, 2020).

In the case of the CNRH, Decree no. 10,000/2019[28] reduced the representation of Brazilian states, water-user sectors and civil society organisations. In addition, this decree allows the FG to edit norms and resolutions *ad referendum*, without the need for a broad debate among the council's members.

The dismantling of Conama was crucial for forest policy. This council has been active as the main decision-making body of the National Environment System (Sisnama) since 1981. Its decisions and resolutions were central to Brazilian environmental policies, making technical and political elements compatible (FONSECA *et al.*, 2012).

In May 2019, the FG issued Decree no. 9,806[29], changing the composition of Conama and its operating rules. The number of Conama councillors was reduced to 23 from 96. FG representation, which was previously guaranteed for all ministries, now only has ministries linked to productive and economic activities. With regard to representatives from civil society, the number of councillors was reduced from 23 to four. In addition, the choice of civil society representatives, which previously involved an

election process, was changed to comprise a random draw. The decree also limited the mandate of civil society councillors to one year, with renewal prohibited.

These changes[30] reduced the importance, decision-making capacity and representativeness of Conama. Specifically, with regard to representation, the proportional weight of the FG increased, and that of civil society decreased. Furthermore, using a random draw to appoint civil society organisations disregards councillors' autonomy and representativeness. Furthermore, limiting the term of office to one year and vetoing renewal makes it difficult for the councillor to have enough time to manage the internal rules of a participatory space known for its highly technical content.

The consequences of the changes at Conama were immediate, as was the revocation of four resolutions in different areas of environmental policy in September 2020. Two of them directly impacted forest policies: Resolutions 302 and 303, which had been in force since 2002. The former demarcated an area of permanent preservation, a 30-meter strip around artificial reservoirs in urban areas, extended to 100 meters in rural areas. The latter regulated articles of the forest code that restricted deforestation in mangroves, sandbanks and dunes. The outcome of this regulation could result in a significant increase in aquaculture, notably shrimp farming, in sandbank areas along a strip of water 300 meters from the beach[31].

5 FINAL CONSIDERATIONS

Governments in democratic societies face two paths: to act or not to act. While acting can mean strengthening intervention mechanisms, it can also take the form of the organised dismantling of these mechanisms. The recent Brazilian political landscape, which has undergone many notable shifts, constitutes a laboratory for the study of decision-making.

This article explores the construction and dismantling of the institutional capacity to control and combat deforestation in the Brazilian Amazon. We have qualitatively analysed the capacity-building and dismantling processes, comparing the results with effective deforestation rates. The data reveal that, in terms of environmental policies, the first two decades of this century displayed a first period characterised by institutional capacity building and then a tendency towards active dismantling.

There was a predominance of capacity building and institutional densification between 2000 and 2012. During this period, the environmental institutional framework expanded, and the number of policy instruments increased significantly, taking advantage of a favourable context: a global trend in pro-environmental protection and the participation of grassroots organisations and socio-environmental movements in government structure and policy. Consequently, environmental policy enforcement was promoted, enabling progressive control over land use changes historically associated with deforestation and a reduction in and relative control of deforestation rates.

The period between 2013 and 2018 can be characterised as ambiguous: on the one hand, the tendency towards densification was maintained; while on the other, some measures reducing institutional density were adopted. The ambiguity identified is related to the organisation and capillarity of agribusiness coalitions and their links with government institutions. In addition, the flexibility of certain rules changed the structure of incentives and the forms of relationship between the State and civil society, diluting the effectiveness of policies. This represented the beginning of a dismantling process. In the final years of this period, it is possible to note the impact of the above on deforestation rates, which rose once more.

The first two years (2019-2020) under Bolsonaro's denialist government have been testimony to a surprising process of institutional deconstruction. The FG is now transforming national environmental policy from a fundamentally different perspective than the one that guided its trajectory in previous

years. The architecture of the command-and-control model itself has been called into question, illustrated by changes in the levels of environmental protection, the extinction of policies, and the exclusion of civil society from the decision-making process.

The soft dismantling during Dilma Roussef's term and the severe dismantling during Bolsonaro's term show that the FG's ideological orientation and the role of advocacy coalitions are fundamental in explaining both capacity building and the dismantling of forest policies in the Brazilian Amazon. As witnessed in deforestation rates for 2019 and 2020, this article has identified an apparent convergence between less command and control and increased deforestation.

The shortest way to undermine environmental protection is to give little importance to the problems by limiting the action of the responsible bodies and reducing budgets or personnel, defined in the literature as a reduction in institutional intensity. However, as highlighted in this article, what is happening in Brazil is much more complex: an active dismantling in which institutional density is significantly reduced. It has impacts not only on enforcement on the ground. It also has a symbolic impact on local actors' discourses and narratives, the way they think, consider risks and benefits, take decisions, and support and manifest behaviours that were not socially accepted a few years ago regarding the environment.

The dismantling of institutional capacity is disturbing in at least two ways. On the one hand, as with civil engineering – which shows that a structure's construction is slower than its implosion – demolishing institutional capacity is easier than building it. On the other hand, regarding the environment and, in particular, rainforest ecosystems, the damage goes far beyond institutional dismantling. Many land use changes are irreversible. Even those areas left for regeneration will take decades to return to pre-deforestation ecological status or may never return to the same biodiversity and ecosystem services. When it comes to the resilience of forests, it is not simply a matter of time before they return to sustainable conditions, and impacts affect the long-term dynamics of the planet. Thus, there is a mismatch between institutional resilience and environmental resilience. Even if the combat and control of Amazon deforestation returned to the path initiated in the early 1990s, a large part of the environmental impact generated by dismantling would be permanent.

The results presented here make it possible to suggest new questions that might inspire further studies. This article focused mainly on institutional density. The data considered in the analysis led to immediate and structural changes, such as laws, decrees and formal regulations. However, changes in institutional intensity are also relevant in explaining dismantling. Actions or inactions that lead to a scarcity of resources, reduction of personnel, changes in the direction and patterns of implementation, and the parameters for guiding policies, as well as symbolic aspects, affect the rise and fall of public policies.

NOTES

1| This paper's acronyms referring to Brazilian institutions will follow the Portuguese standard.

2| The data published by Inpe in 2000 refers to deforestation actions effectively carried out in the previous year (1999).

3| We use the term dilution to express closing FG institutions and/or the revocation of policies or regulations.

4| This comprises FHC's second term, Lula's two terms and the first two years of Dilma Rousseff's first term.

5| Law n° 9.605, February 12th, 1998. Available at: http://www.planalto.gov.br/ccivil_03/LEIS/L9605.htm. Accessed on: 11/02/2021.

6| Provisional Measure n° 2.166-67, August 24th, 2001. Available at: http://www.planalto.gov.br/ccivil_03/mpv/2166-67.htm. Accessed on: 11/02/2021.

7| Available at: http://www.planalto.gov.br/ccivil_03/LEIS/L9985.htm. Accessed on: 11/02/2021.

8| Law n° 11.284, March 2nd, 2006. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2006/Lei/L11284.htm. Accessed on: 11/02/2021.

9| Law n° 11.516, August 28th, 2007. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2007/Lei/L11516.htm. Accessed on: 11/02/2021.

10| Decree n° 6514, July 22nd, 2008. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2008/Decreto/D6514.htm. Accessed on: 11/02/2021.

11| Decree n° 6.527, August 1st, 2008. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2008/Decreto/D6527.htm. Accessed on: 11/02/2021.

12| Law n° 12.187, December 29th, 2009. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2009/Lei/L12187.htm. Accessed on: 11/02/2021.

13| The Brazilian target of reducing between 36,1% and 38,9% of its greenhouse gas emissions by 2020 was presented during the COP 15, in Copenhagen, in 2009.

14| Developmentalist refers to an approach that values economic development over environmental sustainability.

15| The Term of adjustment is a legal instrument that establishes obligations and conditions for repairing environmental damage or changing courses of action by landowners or private corporations.

16| Law n° 12.651, May 25th, 2012. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12651.htm. Accessed on: 11/02/2021.

17| Environmental liabilities mean the portion of the rural property that was irregularly deforested or deviating from its expected land use.

18| Provisional Measure n° 870, January 1st, 2019; later became the Law n° 13.844, June 18th, 2019. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2019/Mpv/mpv870.htm. Accessed on: 11/02/2021.

19| In June 2021, Salles resigned from the ME after being investigated by the Brazilian Supreme Court (STF) for involvement in the illegal timber trade. The new Minister is Joaquim Leite, Salles' former secretary for the Amazon. Leite was an advisor to the Brazilian Rural Society (SRB) for two decades and is a member of the same anti-environmental advocacy coalitions as Salles.

20| Decree n° 9.672, January 2nd 2019. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/decreto/D9672.htm. Accessed on: 11/02/2021.

21| Decree n° 9.922, July 3rd 2003. Available at: http://www.planalto.gov.br/ccivil_03/DNN/2003/Dnn9922.htm. Accessed on: 11/02/2021.

22| Normative Instruction n° 7, February 21st 2020. Available at: http://www.ibama.gov.br/component/legislacao/?view=legislacao&legislacao=138707. Accessed on: 11/02/2021.

23| Decree n° 9.760, April 11th 2019. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/Decreto/D9760.htm. Accessed on: 11/02/2021.

24| Law n° 13.887, October 17th, 2019. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/Lei/L13887.htm. Accessed on: 11/02/2021.

25| Decree n° 9.759, April 11th 2019. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/decreto/D9759.htm. Accessed on: 11/02/2021.

26| The STF decided to limit the scope of Decree 9.759/2019. The STF's decision pointed out that the presidential decree could not eliminate councils whose existence was stipulated by law.

27| Decree n° 10.224, February 5th 2020. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/decreto/D10224.htm. Accessed on: 11/02/2021.

28| Decree n° 10.000, September 3rd, 2019. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2019/Decreto/D10000.htm. Accessed on: 11/02/2021.

29| Decree n° 9.806, May 28th, 2019. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/decreto/D9806.htm. Accessed on: 11/02/2021.

30| Internal Regulation of the National Environment Council. Available at: http://www2.mma.gov.br/port/conama/processos/503DCE74/RI_VLimpa61aRE.pdf. Accessed on: 11/02/2021.

31| Changes to Resolutions 302 and 303 were suspended by the STF at the time this article was being completed.

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The SDGs and the perspective of education for sustainability in the educational program of undergraduate biology courses in the Amazon region of Pará

Os ODS e a perspectiva de educação para a sustentabilidade nos projetos pedagógicos de cursos de licenciatura em biologia da região amazônica paraense

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ABSTRACT

The objective of this research was to identify the presence of Sustainable Development Goals (SDGs) in the Educational Programs (EPs) of undergraduate biology courses in the Amazon region of Pará, as well as to characterise the approach these documents take to education for sustainability. Both quantitative and qualitative document analyses were carried out, which identified that five of the 17 SDGs are present in all EPs, two were not found in any of them, and another three were present in 80% of the documents. Although they do not explicitly explore the SDGs and the concept of education for sustainability, some documents carry similarities with this perspective, as they point to the need for training professionals with socio-environmental responsibility. The research presents practical contributions, both from scientific and social points of view, which can be used in documents' guidelines and necessary actions for executing undergraduate courses coherently with the principles of education for sustainability.

Keywords: Guiding documents. Education. Amazon ecosystems. Initial education.

RESUMO

O objetivo desta pesquisa foi identificar a presença dos Objetivos de Desenvolvimento Sustentável (ODS) nos Projetos Pedagógicos de Cursos (PPCs) de licenciatura em biologia da região amazônica paraense, bem como caracterizar a abordagem que esses documentos fazem sobre a educação para a sustentabilidade. De natureza quantitativa e qualitativa, foi realizada uma análise documental, a qual identificou que cinco dos 17 ODS estão presentes em todos os PPCs, sendo que dois não foram

encontrados em nenhum deles e outros três se fizeram presentes em 80% dos documentos. Embora não explorem os ODS e o conceito de educação para a sustentabilidade de forma explícita, observam-se aproximações com essa perspectiva em alguns documentos, uma vez que eles apontam para a necessidade da formação de um profissional com responsabilidade socioambiental. A pesquisa apresenta contribuições práticas, tanto do ponto de vista científico quanto social, as quais poderão ser usadas no direcionamento de documentos e atuações essenciais para a execução de cursos superiores, preocupados e condizentes com os princípios da educação para a sustentabilidade.

Palavras-chave: Documentos norteadores. Educação. Ecossistemas amazônicos. Formação inicial.

1 INTRODUCTION

In today's world, the act of teaching goes beyond objectives and assignments related to topics, contents, descriptors, and the achievement of internal and/or external indicators for the educational institution. Education must be present from the very first moment in actions aimed at today and tomorrow, in a contextualised manner and concerned with the environment where its subjects are located, in addition to enabling both current and future practical applications.

Thus, educating for sustainability implies envisaging a new guideline for teaching practice, emphasising active learning situations and collaborative experiences to solve local, regional, and global problems. This guiding activity requires a new way of thinking about teaching and learning (FREIRE, 2007).

Petrovich *et al.* (2016), however, emphasise that guaranteeing education for sustainability means being vigilant in training future teachers. It is imperative, therefore, to train professionals not to reproduce old knowledge transmission models, thus avoiding spreading science and culture that cause environmental degradation.

With this perspective, the initial education of science and biology teachers represents an ideal space for discussions and learning about science and its nature since it is based on the initial insight of the functioning and contextualisation of science that future teachers will teach their students (BACCIN; DUTRA; COUTINHO, 2020).

In order to train teachers to commit to sustainability education, the personnel and documental bases that support and establish the initial education of these professionals need to be engaged in the topic. In addition, faculty members, management, institution, and community should all be guided by the legal and documental principles that ensure professionals in training develop ideas, changes, and actions committed to local, regional, and global sustainability.

One of these principles is the Educational Program (EP), a guiding document that describes objectives, guidelines, actions, and planning of the educational process, to form a social, critical, supportive, committed, creative, and participative subject (FREITAS, 2018). The document thus needs to follow dimensions that ensure perspectives of education for sustainability to the subjects in training.

Therefore, this research has the following guiding questions: How is education for sustainability addressed in the EPs of undergraduate biology courses in the Amazon region of Pará? Do these documents comprise the training of professionals concerned with the local reality and following the Sustainable Development Goals (SDGs)?

Based on the questions mentioned, it is worth highlighting that the SDGs proposed by the 2030 Agenda constitute guidelines for social responsibility, working as normative principles of action and as an agenda of concerns that guides different stakeholders with a focus on problem-solving (FERNANDES,

2018). The SDGs are thus a universal call to action to end poverty, protect the environment, reduce climate change and ensure that all people enjoy peace and prosperity.

According to Freire (2007), one cannot think of a sustainable community if it is not concerned with training practices; therefore, such an approach is imperative. Along these lines, the 17 SDGs proposed by the 2030 Agenda are formed by global goals grouped in four dimensions: social, economic, environmental, and institutional. These dimensions are interrelated and point to the need for bringing the global goals closer to the local problems of each city (UN, 2015), which can only be achieved through education.

In light of the approach presented, the objective of this research was to identify the presence of SDGs in the EPs of undergraduate biology courses in the Amazon region of Pará, and to characterise the approach these documents take to education for sustainability.

2 EDUCATION FOR SUSTAINABILITY IN UNDERGRADUATE BIOLOGY COURSES

Initial education as professional training plays a crucial role in enabling teachers to adopt specific knowledge and to experience, in their learning process, the development of the necessary skills to act in this new setting (BACCIN; DUTRA; COUTINHO, 2020). Therefore, for undergraduates in biological sciences, the performance context focusses on aspects such as the responsibility of acting in the study and care of most diverse forms of life on planet or associated with the development of citizens aware of their rights, duties, and responsibilities towards the environment they are located in.

From this perspective, higher education, especially in the area of biology, has the responsibility of strongly contributing to the formation of a plurality of people who might exercise leadership roles in different areas of activity, as well as those who may come to work directly with the education of other people.

Consequently, it is considered extremely important to offer education from an integrated and interdisciplinary perspective, in which sustainability can be transversal in the different areas of knowledge. Moreover, once aware, these students will be able to work to disseminate values and change mentality in society, thus contributing to an ecologically viable future (PETROVICH *et al.*, 2016).

The university in present times must be arranged to educate critical professionals and raise their awareness of the environmental reality (STANQUEVISKI, 2019). Besides, commitment to the environment at local, regional, and global levels is strictly related to the practice of science and biology teachers. Therefore, these professionals must develop the sensitivity to work alongside other individuals in training and awareness processes for the planet's welfare.

With access to the principles and approaches of education for sustainability, these professionals will have more significant subsidies in acting against negligence and disservices caused by the government and/or directors of institutions where they might work. Moreover, such diligence can make a difference in other individuals' teaching and learning processes and will add to the fight for the overall improvement and welfare of the planet.

For Gadotti (2008a), educating for sustainability is, essentially, educating for a sustainable life, which means, among other things, educating for voluntary simplicity and stillness. Accordingly, Antunes, Nascimento, and Queiroz (2018) highlight that education for sustainability arises from the need to design new directions for problems that afflict society, seeking to reflect on the possibilities that education presents for these problems fostering a fairer society for the current and future generations.

It is, therefore, understood that universities have great relevance in the reflection, formation, and dissemination of new concepts of development and sustainability, participating in the construction of another culture, thus meeting the aspirations of more just, solidary, and environmentally sustainable societies (OLIVEIRA, 2017).

Responsible for the initial and continuing education of science and biology teachers, as well as other areas, Higher Education Institutions (HEI), in addition to fulfilling their role as a legal entity within a physical environment, have the mission and duty to build an "environmental awareness" in future professionals. This awareness process will contribute to the human capacity to reverse the increasing degradation of the environment and establish planetary sustainability (SILVA; BASTOS; PINHO, 2021).

It is worth highlighting that the institutional environment, along with its curricular, professional, and attitudinal structure towards society, has a substantial and essential influence on individuals' academic and human development. All this contributes to future actions professionals in training may develop that are linked to the socio-environmental needs of the planet. In addition to possible advances and improvements that future educators will be able to bring as a contribution to society, the environment, and overall welfare.

In this context, Gomes and Ferreira (2018) point out that the SDGs show a combined mechanism of efforts and daily practices aimed at promoting the welfare of the present generations and intergenerational justice without disregarding the welfare of future generations.

Thus, by being present in the educational foundation of new professionals in the area of biological sciences, the SDGs may also be present in the professional path to be followed by these individuals, adding values of education for sustainability that are essential in becoming aware of the needs of the planet. In addition, they can contribute to improving socio-environmental problems and harmony of life in all its aspects.

3 METHODOLOGICAL OUTLINE

3.1 RESEARCH DESIGN

This research has quantitative and qualitative approaches, with a methodological procedure based on document analysis, as this type of method has the objective of understanding a given reality, not in its immediate realisation, but indirectly, through the analysis of documents produced by humans about themselves (MENDES; FARIAS; NÓBREGA-THERRIEN, 2011).

With this approach, the research is divided into five stages: a) Delimitation of the research locus; b) Research of the EP in its most current publication in the public domain on the institution's website; c) Construction of an analysis tool that can reflect the approach that the documents take to the SDGs; d) Analysis of the EPs selected in stage "a", using the instruments built in stage "c"; e) Data analysis relating the identification of concepts and actions associated with education for sustainability present in the EPs through the identification of the SDGs in the instrument.

3.2 RESEARCH SETTING

The Amazon is known for housing a significant biological diversity in its ecosystems. However, in recent decades it has suffered the effects of climate change and anthropic action in different ways, presenting profound and perhaps irreversible changes in its biome, which can lead to regional, national, and global impacts (FERREIRA; VENTICINQUE; ALMEIDA, 2005).

Among the Brazilian states that comprise this ecosystem, Pará is the second in territorial extension, having areas of more recent colonisation, such as the southeastern part of the state. However, the oldest colonisation areas, such as Bragantina and Baixo Tocantins, are located in the northeastern mesoregion of the state (ALMEIDA, 2010).

As the setting of the research, five HEIs located in the Amazon region of Pará were chosen according to the selection criteria: a) HEIs that offer an undergraduate course in biology, biological sciences, or natural sciences with a qualification in biology or related topics; b) The biology course offered must be at least five years old; c) The institution's campus must be located in the Amazon region of Pará.

From this criteria, the following undergraduate courses were selected for this study: 1) Biological Sciences offered by the Federal Institute of Pará (IFPA) - Abaetetuba *Campus*; 2) Biological Sciences offered by the Federal Institute of Pará (IFPA) - Belém *Campus*; 3) Biological Sciences offered by the Federal University of Pará (UFPA) - Belém *Campus*; 4) Natural Sciences with a qualification in biology offered by the State University of Pará (UEPA) - Moju *Campus*; and 5) Biological Sciences offered by the Federal Institute of Pará (IFPA) - Bragança *Campus* (Figure 1).

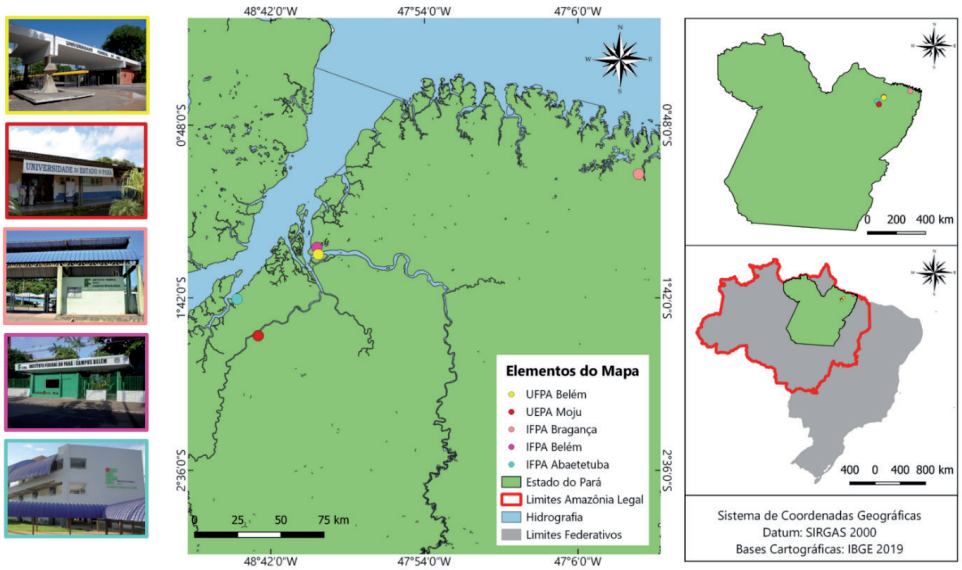

Figure 1 | Location map of the institutions participating in the research.

Source: Produced by the authors (2022).

As a way of preserving the identities of educational institutions in the tabulation, expression, and discussion of the results obtained, names of HEIs were randomly replaced by acronyms: EI1, EI2, EI3, EI4, and EI5.

3.3 RESEARCH INSTRUMENT AND OBJECTS

The instrument used in the document analysis was developed so that the analysis favoured the identification of SDGs in the documents, based on topics that are closely related to education for sustainability. In addition, such instruments were inspired by methodologies previously used by Castilho, Peña and Gil-Pérez (2021) and Lima (2020) in works with similar objectives.

The instrument (Table 1) consisted of the description of the 17 SDGs, followed by three search keywords for each. The word choice is intended to reflect the representativeness of the SDG in the analysed document through keywords related to the goal under analysis. In addition, the instrument presents a description of topics related to the SDGs and the keywords, followed by gaps to be filled in

during analysis to verify the presence, absence, and context in which the analysed word appears in the document (if present).

Table 1 | Instrument for the analysis of Educational Programs (EPs) in Biological Sciences in the Amazon region of Pará.

Sustainable Development Goals	*Search keyword*	*Related topics*	*PR**	*AB***	*Context*
01- No Poverty	Poverty	- Unequal income distribution, wealth, and extreme poverty; - Public policies for the poor and vulnerable and against inequality.			
	Vulnerability				
	Eradication				
02- Zero Hunger	Hunger	- Food waste; - Monoculture, transgenics, pesticides and insecticides.			
	Food security				
	Sustainable agriculture				
03- Good Health and Well-Being	Health	- Contagious diseases, sexually transmitted infections, mental disorders, and drug addiction; - Health promotion.			
	Well-being				
	Life expectancy				
04- Quality Education	Inclusive education	- Illiteracy and related factors; - Discrimination related to cultural diversity and disregard for historical and natural heritage.			
	Equal education				
	Teaching-learning				
05- Gender Equality	Gender equality	- Gender inequality and access to rights; - Workplace democracy, economic rights, equity.			
	Women's empowerment				
	Discrimination against women				
06- Clean Water and Sanitation	Clean water	- Water wastage and contamination; - Drinking water, water reuse, and basic sanitation.			
	Sanitation				
	Water resources				
07- Affordable and Clean Energy	Renewable energy	- Wind energy, solar energy, tidal energy, geothermal energy, hydropower energy, etc.; - Saving energy and energy resources.			
	Affordable energy				
	Energy efficiency				
08- Decent Work and Economic Growth	Economy	- Slave labour, economic crisis (unemployment, low wages, inflation); - Subsistence agriculture, handicraft work, fishing, tourism.			
	Sustainable development				
	Employability				
09- Industry, Innovation, and Infrastructure	Industrialisation	- Sustainable construction (energy efficiency, water saving, and reuse, technologies and materials that do not harm the environment); - Waste management, passive use of natural resources, reuse.			
	Sustainable infrastructure				
	Industrial innovation				

Sustainable Development Goals	Search keyword	Related topics	PR*	AB**	Context
10- Reduced Inequalities	Social inclusion Social inequality Social policies	- Unequal income distribution, wealth and extreme poverty, public policies for the poor and vulnerable; - Prejudices (racism, misogyny, LGBT-phobia, xenophobia, etc.			
11- Sustainable Cities and Communities	Urban sustainability Cultural heritage Urban resilience	- City planning; - Sustainable construction, water saving and reuse, waste management, and passive use of natural resources.			
12- Responsible Consumption and Production	Sustainable management Natural resources Waste reduction	- Waste disposal and treatment, recycling, reuse, reduction, and restoration; - Emission of greenhouse gases from burning fossil fuels and cars.			
13- Climate Action	Climate change Natural disasters Environmental policies	- Drought and global water shortage, floods; - Natural disasters (wildfires, tsunamis, storms, hurricanes, tornadoes).			
14- Life Below Water	Aquatic ecosystems Conservation of aquatic biodiversity Water pollution	- Increase in ocean temperature and level, marine pollution; - Loss of marine biodiversity.			
15- Life on Land	Terrestrial ecosystems Biodiversity Environmental preservation	- Loss of marine and terrestrial biodiversity, extinction, and trafficking of fauna and flora species; - Degradation of ecosystems and biomes, ecological relationships, ecosystem services, actions for protecting and preserving the environment, and rehabilitation of species.			
16- Peace, Justice, and Strong Institutions	Social justice Peaceful societies Social equality	- Citizen action and social responsibility; - Armed conflicts, insecurity (robberies, burglaries, murders), and violence.			
17- Partnerships	Globalisation Transparency in public policies Social responsibility	- Relationship and partnership within and between countries; - Advances in science, technology, economy, etc.			

**Presence of the word in the analysed document. **Absence of the word in the analysed document.*
Source: Produced by the authors (2022).

3.4 DATA COLLECTION AND ANALYSIS

The most recent EP of each course selected for the research was downloaded directly from the institutions' official websites and saved in PDF format. Then, the EPs were digitally analysed through the Adobe Acrobat Reader's search tool (Ctrl + F) to find keywords in the document.

After analysis, the data were tabulated in an Excel 2017 spreadsheet considering the categories "present", "absent" and "context", according to how the group of three keywords considered for each SDG appeared in the document.

With this information, the context of the searched words was assessed based on content analysis which, according to Santos (2012), is a "deep" reading, determined by the conditions offered by the linguistic system, and it aims to discover the relationships between the content of speech and the external aspects. In addition, this technique allows the understanding, use, and application of certain content, promoting the interpretation of the approach to the topic of education for sustainability in the EPs of the courses under analysis.

It is worth mentioning that the document (EP) was read in its entirety, but with emphasis and greater attention to the parts in which the keywords were located. This reading is part of the content analysis process, analysing the presence and/or absence of the keywords in the text, and their meaning and context, interpreting them in the construction of the EP.

In addition, a quantitative analysis of the data was carried out in the Past software version 4.07b, to present a chart with the frequency of the keywords that represent the SDGs found in the institutions' EPs.

4 RESULTS AND DISCUSSION

4.1 GENERAL ASSESSMENTS ABOUT THE PRESENCE OF SDGS IN THE EPS OF UNDERGRADUATE BIOLOGY COURSES IN THE AMAZON REGION OF PARÁ

The analysis of the presence and/or absence of words related to the SDGs in EPs of the courses considered in this research showed that of the five educational institutions examined, SDGs 3, 4, 8, 15, and 16 were found in all EPs. In contrast, SDGs 5 and 11 were not found in any documents, and SDGs 10, 12, and 14 appeared in 80% of the documents analysed (Table 2).

Table 2 | Occurrence of SDGs in EPs of the institutions considered in the research.

Sustainable Development Goals	*Educational Institutions Considered in the Research*				
	EI1	EI2	EI3	EI4	EI5
1		X			
2		X			
3	X	X	X	X	X
4	X	X	X	X	X
5					
6		X	X	X	
7					X
8	X	X	X	X	X
9					X
10	X	X	X		X
11					

Sustainable Development Goals	Educational Institutions Considered in the Research				
	EI1	EI2	EI3	EI4	EI5
12	X	X	X	X	
13		X			X
14		X	X	X	X
15	X	X	X	X	X
16	X	X			X
17		X	X	X	X
Total	7	13	9	8	11

Source: Research data.

By expressing the aims and principles of a particular SDG, the document that guides the course can plan new advances and improvements, as long as they are well oriented and thought out. This is because the SDGs claim efforts for genuinely overcoming the problems that affect humanity and the environment over the years. Therefore, it is relevant to point out that the SDGs' central purposes are similar to the dimensions of sustainability (GOMES; FERREIRA, 2018).

For Corrêa and Ashley (2018), higher education commonly incorporates the agenda of environmental education, sustainability, and sustainable development with different interpretations and approaches in educational programs and curricula, in institutional documents, in everyday speeches, in teacher training, and the contents and practices of teaching and learning. However, there is still not enough dialogue maturity in many cases to understand such issues.

For a more in-depth analysis of how the EPs address the SDGs, Figure 2 shows the frequency of keywords corresponding to the SDGs that were detected in all EPs (SDGs 3, 4, 8, 15, and 16) of the five institutions, and EI3 and EI2 were the ones that most expressed words related to these SDGs in their EPs.

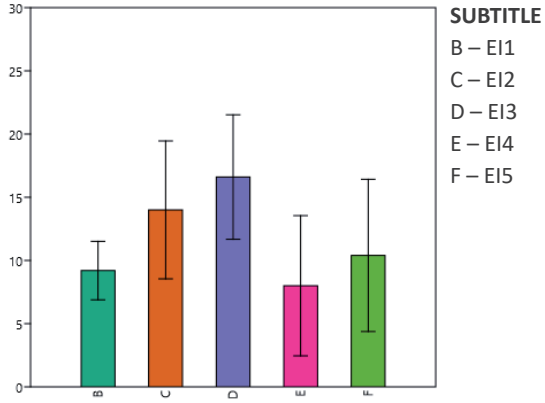

Figure 2 | Frequency of keywords representing the SDGs detected in the five institutions analysed.

Source: Research data.

It is possible to infer from the chart that EI3 and EI2, by showing a significant frequency of keywords related to the SDGs in question, stand out as institutions that are mindful of topics such as health, well-being, social responsibility, and quality education, labour conditions, and terrestrial ecosystems. Such

concern in the initial education of future professionals in biological sciences aligns with the principles of education for sustainability.

This shows, for example, that when EI2 states in its EP "the education of future professionals promotes the understanding of the historical process guiding the construction of knowledge in the area of biology. Besides, it highlights the importance to society through education, of various aspects of its socio-political performance and for the practice of sustainable development in the country", the institution is clearly in compliance with SDG 4 (quality education). Thus, the institution demonstrates that the course is committed to building knowledge in biology, whose importance lies in the sustainable development of the country and the region where it is located.

It shows that EI2 and EI3, based on the considerable frequency of words related to SDGs 3, 4, 8, 15, and 16, are not only under the perspectives of education for sustainability in the education of their professionals, which would already be of great value. They are also interested in the qualification of their future professionals. Such interest derives from the concern above mentioned HEIs have in educating citizens to respect and contribute to the sustainable development of the Amazon, a region where the courses take place and where most professionals will work after graduation.

In this context, Guerra and Figueiredo (2014) draw attention to the fact that curricular environmentalisation can be defined as a continuous and dynamic process aimed at educating professionals to be committed to the permanent search for the best possible relationships between society and nature. Therefore, seeking to educate professionals involved with the region's social and environmental issues is a first step in the continuous education process and adoption of values to be considered and worked on throughout the life of the human being.

In other passages, for example, EI3 states in its EP that the course aims to "interact with modern approaches and principles of sustainable development, relating educational knowledge with biological knowledge", in addition to "educate holistic, critical, autonomous and humanitarian professionals for the exercise of citizenship and social responsibility".

Consequently, there is a context that approaches SDGs 8 (decent work and economic growth) and 17 (partnerships) since the institution seeks an education focused on society, meeting social and humanistic responsibility principles. It is believed, however, that this type of education leaves something to be desired in the environmental approach, given that both approaches (social and environmental) deserve equal attention and concern in the education of a qualified professional responsible for the well-being of current and future generations.

When seeking education in this manner, institutions agree with Freire (2007), who states that the global crisis that humanity is experiencing is the result of our way of life and our collective values and, therefore, it can be considered a cultural crisis. However, culture plays a central role in the complex notion of sustainability in whatever form it takes in the future, as it depends on our decisions and actions at a local level.

It is also important to point out that all institutions address SDG 4 in their EP to ensure access to inclusive and quality education. However, some institutions stand out, such as EI1. It aims to "minimise the effects of social and regional inequalities on the permanence and completion of higher education". On the other hand, EI3, aims to "be mindful of the reality in which it will operate and the need to become a transforming agent of such reality, aiming to improve the quality of life of the human population, assuming its responsibility in the preservation of biodiversity as a heritage of humanity".

Regarding the curricular components that comprise the courses' EPs and their respective approaches, it can be noted that EI2 and EI3 contemplate the various dimensions considered by the 2030 Agenda regarding the SDGs (social, economic, environmental, and institutional goals).

The different axes of curricular components within the EP are a positive factor, as education for sustainability should not be limited to one subject or module within the course. However, it must be present throughout the course, from teaching to research and community activities. In the documents of the other institutions, it was possible to observe the prevalence of some dimensions, but never all four.

Therefore, the inclusion of topics related to the principles of education for sustainability in the curriculum of initial education becomes essential regarding the process of raising awareness of the academic community about the importance of environmental sustainability, which is a topic that should permeate the diversity of academic subjects and practices in HEIs. It can be combined with adequate management and full cooperation between the various institutional bodies and, under current regulations, involving all who are part of it, such as staff, faculty, and students (SANTOS, 2018).

Individually, it is possible to note that, although it mentions a few keywords from the data collection instrument, EI5 contextualises them vaguely and superficially, thus not allowing an actual definition of their importance to the institution. On the other hand, EI1, EI2, EI3, and EI4 seem more engaged in expressing the concepts related and contextualised with the SDGs, even though they do not directly mention the goals in the documents.

In this research, EI2 is the institution that most addresses the concepts, goals, and principles of education for sustainability through the presence of SDGs in its EP. This occurs not only because it expressed 13 of the 17 SDGs, but also through the homogeneity of approaching these principles. Furthermore, from the introduction to the objectives and description of the curricular components of the course, it was possible to identify elements related to the objectives of the SDGs and are associated with the context pointed out in the analysis instrument developed in this study.

Therefore, rethinking the initial education of science and biology teachers following the SDGs and from the perspective of education for sustainability should be a priority in all HEIs. This action can help these future teachers to re-elaborate and re-signify spaces and learning situations in the school environment. It can also encourage them to participate in forming interdisciplinary teams on the sustainability topic at school (PETROVICH *et al.*, 2016).

Thus, it is understood that this is a measure that actively helps the school community to adopt and prioritise issues related to education principles for sustainability in the educational environment.

4.2 WHAT DO EPS EXPRESS ABOUT EDUCATION FOR SUSTAINABILITY?

It was possible to observe that none of the analysed EPs had, directly and explicitly, the application and contextualisation of the term "education for sustainability". However, based on the context of the SDGs, there were expressions and excerpts in the documents referring to the principles of education for sustainability, which allowed recognising the consonance between the approach to sustainability and the purposes of the course through its EP, albeit in a subtle way.

In this perspective, Gadotti (2008a) points out that educating for sustainability implies changes in the system and respect for life, including everyday care for the planet and the entire community of life. To educate for life, EI4, for example, emphasises in its EP that the biologist must be able to solve some obstacles, among which the following is mentioned: “the biology teacher must use biological knowledge to awaken a sense of responsibility in basic education students".

Therefore, one can perceive the great responsibility of trained professionals concerning their functions. This is because, by educating citizens to be aware of their social responsibilities, these professionals will be responsible for the care and maintenance of life on the planet, in addition to being in line with SDG 16 (peace, justice, and strong institutions) and 17 (partnerships).

Moreover, Unesco (2017) points out that education for sustainability fosters the development of better-informed citizens with new values, skills, attitudes, and behaviours, ensuring harmony and balance between social and ecological processes. Along these lines, EI2 demonstrates in its EP, on environmental education policies, that “sustainable development is one of the values that guide the institution’s actions, being essential for it to act in line with current social, environmental and economic issues, and should be widely disseminated in order to support the development of citizens who are critical and aware of their role in society”.

However, it was found through content analysis that although the institution uses the term “sustainable development” in its EP, as shown in the excerpt above, the concept used is more associated with the principles of education for sustainability. This is one of the recurrent cases in which the use of the terminologies “sustainable development” and “education for sustainability” is mistaken.

Effectively, the institution values the development of critical and conscientious citizens before society’s problems, aspiring thus that their actions after graduation may reflect the type of education received during undergraduate studies. This fact aligns with SDG 8 (decent work and economic growth) and with the principles of education for sustainability.

In addition, the EPs are interested in having professionals aware of their responsibility towards the planet's biological diversity at local and global levels. It is understood, therefore, that since biodiversity is essential for the maintenance of life on earth, promoting professional awareness about interferences in the environment is necessary for disseminating and executing the principles of education for sustainability.

Higher education has a priority role insofar as future professionals are the ones who will have to work with the social, environmental, and economic resources. Such professionals need, therefore, to realise their role in the search for social transformations and improved well-being for current and future generations (LOUREIRO; PEREIRA; PACHECO JUNIOR, 2016).

In this perspective, EI2, in the topic of general competencies to develop in the education of graduates in biological sciences, considers it essential to "conduct educational practices that are consistent with reality and concrete possibilities of education in the process of social transformation, aiming at collective welfare”, which can be related to SDG 10 (reduced inequalities). Therefore, the institution proposes the possibility of behavioural changes and comprehensive social education to its students, presenting practical action perspectives that support the community and the environment.

Considering the social purpose of educational institutions, education for sustainability comprises more participatory learning, which creates ways of building more contextualised and, therefore, more meaningful knowledge. Participation, co-creation, and co-responsibility are thus deemed as central aspects of this approach, focusing on the importance of collective, collaborative, and democratic processes in the search for more sustainable societies (GRANDISOLI *et al.*, 2020).

It is understood that undergraduate biology science courses should offer students teaching and learning practices that encourage them to transform society and participate in its problems. Then, facing such problems, they will be able to think critically about innovative solutions within sustainability principles.

Such actions can be seen in the EP of EI4, on the topic of living beings and the environment: “knowing the main environmental problems, such as pollution, exploitation of natural resources, global changes, conservation, and development". This aspect is part of the duties of the professional in training, thus elucidating the confrontation that future teachers will experience in their professional life. It is worth mentioning that appropriate training can contribute towards pointing out solutions to the problems experienced.

In this context, Carletto and De Oliveira (2017) draw attention to the fact that the teacher, as a social actor and mediator of students' demands for society, needs to discern the problems of their sector with a view to the educational purpose of their practice and, thus, fulfil their role, contributing to the complete development of citizens.

4.3 PERSPECTIVES AND POSSIBILITIES FOR NEW PATHS AND APPROACHES

Pointing out possibilities for new paths and perspectives that could be adopted by undergraduate biology courses in the Amazon region of Pará does not mean dictating rules or a magic recipe. Instead, it means exposing perceptions based on this study about the guiding documents of a sample of courses in the region, an intersection with the SDGs. The intention is thus to identify possible effects and applications carried out by one institution that, when added together, may present more significant results regarding the principles pointed out.

For Pereira *et al.* (2013), some changes are essential for creating a more sustainable society, as there is no way to maintain the current form of unbridled consumption, which requires a global rethinking in search of a more egalitarian society. Along these lines, the EP of EI2 points out that the course's curriculum framework must "provide the students with a holistic, critical, autonomous and humanitarian education, guiding them to the exercise of citizenship, the respect for human rights and the social responsibility they have as a biology professional". With this approach, it is possible to develop future professionals concerned with social equality and aware of their role in society and the planet, contributing to the improvement and harmony of both.

Therefore, as teacher trainers, universities must provide qualifications consistent with their role as agents of change in the new model of citizenship demanded by today's society. They should include, among other aspects, the dimension of sustainability in the education of its students (ALARCÃO *et al.*, 2018).

Regarding this dimension, EI2 also points out that biology graduates should "be mindful of the reality in which they will work and the need to become a transforming agent of such reality". This approach is under the definition of sustainability presented by Boff (2012), who relates the term to the concern with the existence and maintenance of natural resources with the possibility of an environment suitable for the continuity of future generations. Similarly, it complies with SDGs 14 (life below water) and 15 (life on land).

However, it will not be possible to qualify professionals aware of their role as belonging to the dimensions of sustainability if the educational institutions do not address, in their courses, the guiding principles and goals of education for sustainability beginning in their normative documents. Conversely, demanding such principles and goals should work as a chain of effects, in which faculty members will be able to use the document as a basis for the development of their activities and, in turn, the students will be based on the dynamics, activities, and principles disseminated by their teachers.

In the EP of EI1, for example, the institution aims to "contribute to the promotion of social inclusion through education", showing compliance with SDG 4 (quality education). It emphasises, with this instrument, that education contributes to social inclusion and many other principles necessary for a collective, harmonious and sustainable life.

In this respect, Gadotti (2008b) considers that the reach of sustainability culture should be in agreement with education for thinking globally, for feelings, for teaching earthly identity, for planetary consciousness, understanding, and voluntary simplicity. It is, therefore, a pedagogical practice that goes from diluted responsibility to concrete and shared action, exercising sustainability in all sectors of our lives.

That being said, it is hoped that the guiding principles of education for sustainability will contribute to a change in governance and the mobilisation of society through education (GROHE; DA SILVA, 2022). Therefore, educational institutions and communities must go through a transition that engages them with preserving the environment and people's welfare.

In this process, teachers are a crucial factor whose training has a multiplier effect that must be reproduced in their future professional careers (VARELA-LOSADA; ARIAS-CORREA; VEGA-MARCOTE, 2019). Educating for sustainability means, in this context, recognising the role of education both in raising awareness of the impact of social organisation on the environment and in the development of societies that are concerned with reducing such impacts in order to establish sustainable models of social organisation (JACOBI; SULAIMAN, 2017).

This study, therefore, considers the need for educators to reflect on concrete actions at all levels of education so that a sustainable future can be created. Such praxis should raise the importance of access to knowledge that instigates discussions about environmental vulnerability with the unbridled exploitation of the planet's resources while proposing practical actions aimed at its sustainability (ARAÚJO, 2021). These measures may help students from EIs in the Amazon region of Pará to do the same, making the educational space an active environment concerned with social and environmental welfare.

5 FINAL CONSIDERATIONS

By identifying the limited existence of studies that investigate the approach that EPs of undergraduate biology courses take on the SDGs and education for sustainability, this study makes its contribution insofar as it identifies and points to the existence of an approach that relates to the SDGs agenda. However, sometimes this occurs indirectly, out of context, or without depth.

When addressing sustainable development goals in their conception, development, and execution context, the investigated institutions are mindful of the prospect of new directions for society and the planet. This demonstrates a concern with the education of new professionals and, consequently, with cultivating a planet with humanity concerned with maintaining life and social and environmental rights for current and future generations.

It was also possible to identify that some institutions are only concerned with growth and social perspectives. Consequently, their courses dedicate great effort and attention to solving problems that will improve the quality of life of the human being, without paying attention, for example, to the fact that such improvement depends directly on protecting the environment in which these individuals are included.

The contributions of this research permeate three dimensions: 1) practical, when it indicates one of the institutions as the one that presents a complete approach to the principles of education for sustainability; 2) theoretical, when it details the approach that the guiding documents of the courses take on the SDGs; and 3) social when it contributes with notes and possibilities of paths for institutions that offer higher education.

The first dimension serves as a guide for other institutions in moments of reformulation and/or construction of their EPs, providing guidelines so that these documents present equity between what is expected of a professional in the area and the concepts and principles of education for sustainability. The second dimension provides an overview of actions humans, through EPs, have on their role in the environment where they are included. Moreover, the third one, based on pointing out different possibilities and paths, makes it possible for future professionals to be increasingly engaged and critical of socio-environmental issues.

It was possible to observe, as future perspectives, the need to update the EPs of undergraduate biology courses not only as a temporal necessity, given the fact that some documents are recent, but as a concern related to contents and socio-environmental issues, in addition to the graduates' view about the need to act under the principles of education for sustainability. This premise gives clarity and objectivity to these principles in the production of documents, thus facilitating the understanding and development of the actions proposed by the course's pedagogical components.

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Os ODS e a perspectiva de educação para a sustentabilidade nos projetos pedagógicos de cursos de licenciatura em biologia da região amazônica paraense

The SDGs and the perspective of education for sustainability in the educational program of undergraduate biology courses in the Amazon region of Pará

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RESUMO

O objetivo desta pesquisa foi identificar a presença dos Objetivos de Desenvolvimento Sustentável (ODS) nos Projetos Pedagógicos de Cursos (PPCs) de licenciatura em biologia da região amazônica paraense, bem como caracterizar a abordagem que esses documentos fazem sobre a educação para a sustentabilidade. De natureza quantitativa e qualitativa, foi realizada uma análise documental, a qual identificou que cinco dos 17 ODS estão presentes em todos os PPCs, sendo que dois não foram encontrados em nenhum deles e outros três se fizeram presentes em 80% dos documentos. Embora não explorem os ODS e o conceito de educação para a sustentabilidade de forma explícita, observam-se aproximações com essa perspectiva em alguns documentos, uma vez que eles apontam para a necessidade da formação de um profissional com responsabilidade socioambiental. A pesquisa apresenta contribuições práticas, tanto do ponto de vista científico quanto social, as quais poderão ser usadas no direcionamento de documentos e atuações essenciais para a execução de cursos superiores, preocupados e condizentes com os princípios da educação para a sustentabilidade.

Palavras-chave: Documentos norteadores. Educação. Ecossistemas amazônicos. Formação inicial.

ABSTRACT

The objective of this research was to identify the presence of Sustainable Development Goals (SDGs) in the Educational Programs (EPs) of undergraduate biology courses in the Amazon region of Pará, as well as to characterise the approach these documents take to education for sustainability. Both

quantitative and qualitative document analyses were carried out, which identified that five of the 17 SDGs are present in all EPs, two were not found in any of them, and another three were present in 80% of the documents. Although they do not explicitly explore the SDGs and the concept of education for sustainability, some documents carry similarities with this perspective, as they point to the need for training professionals with socio-environmental responsibility. The research presents practical contributions, both from scientific and social points of view, which can be used in documents' guidelines and necessary actions for executing undergraduate courses coherently with the principles of education for sustainability.

Keywords: Guiding documents. Education. Amazon ecosystems. Initial education.

1 INTRODUÇÃO

No mundo atual, a ação de educar vai além de objetivos e tarefas relacionados a temas, conteúdos, descritores e alcances de indicadores internos e/ou externos para a instituição educadora. A educação deve estar presente desde o primeiro momento em ações voltadas para o hoje e o amanhã, contextualizada e preocupada com o ambiente onde estão situados seus sujeitos, além de possibilitar aplicações práticas tanto atuais quanto futuras.

Posto isso, educar para a sustentabilidade implica perspectivar uma nova orientação para a prática letiva, enfatizando situações de aprendizagem ativa e experiências colaborativas e dirigidas para a resolução de problemas nos níveis local, regional e global. Tal atividade norteadora requer um novo modo de pensar o ensino e a aprendizagem (FREIRE, 2007).

Petrovich *et al.* (2016), no entanto, destacam que garantir uma educação para a sustentabilidade significa estar vigilante à formação dos futuros professores. É imperativo, portanto, formar profissionais que não reproduzam antigas fórmulas de transmissão do conhecimento, evitando, assim, difundir uma ciência e uma cultura que servem para a degradação do planeta.

Com essa perspectiva, a formação inicial de professores de ciências e biologia configura-se como espaço ideal para discussões e aprendizagem acerca da ciência e de sua natureza, pois é a partir dessa visão inicial de funcionamento e contextualização da ciência que esses futuros professores ensinarão seus alunos (BACCIN; DUTRA; COUTINHO, 2020).

Para formar professores comprometidos com a educação para a sustentabilidade, as bases documentais e pessoais que sustentam e estabelecem o curso de formação inicial desses profissionais necessitam estar envolvidas com a temática. Professores formadores, coordenação, direção, instituição e comunidade deverão ser guiados pelos pilares legais e documentais que garantam aos profissionais em formação o desenvolvimento de ideias, mudanças e ações comprometidas com a sustentabilidade local, regional e global.

Um desses pilares é o Projeto Pedagógico do Curso (PPC), tido como um documento norteador que detalha objetivos, diretrizes, ações e planejamento do processo educativo, para formar um sujeito social, crítico, solidário, comprometido, criativo e participativo (FREITAS, 2018). Argumenta-se, com isso, que o referido documento precisa ser pautado em dimensões que garantam perspectivas da educação para a sustentabilidade aos sujeitos em formação.

Assim, apontam-se os seguintes problemas norteadores desta pesquisa: Como a educação para a sustentabilidade está sendo abordada nos PPCs dos cursos de licenciatura em biologia situados na Amazônia paraense? Esses documentos preveem em suas bases a formação de profissionais preocupados com a realidade local e em acordo com as metas dos Objetivos de Desenvolvimento Sustentável (ODS)?

A partir dos problemas apontados, destaca-se que os ODS propostos pela Agenda 2030 se constituem como linhas orientadoras da ação socialmente responsável, funcionando como princípios normativos de atuação e como agenda de preocupações que orienta os diferentes interessados, de modo que seu alcance se concentre na resolução de problemas (FERNANDES, 2018). Dessa forma, os ODS se configuram como um apelo global à ação de acabar com a pobreza, proteger o meio ambiente, reduzir as mudanças climáticas e garantir que as pessoas, em todos os lugares, possam desfrutar de paz e prosperidade.

Segundo Freire (2007), não se pode pensar em uma comunidade sustentável se esta não se preocupar com ações formativas e, por isso, tal atitude constitui um imperativo. Em atitude corroborativa, os 17 ODS propostos pela Agenda 2030 são formados por metas globais agrupadas em quatro dimensões: social, econômica, ambiental e institucional. Essas dimensões se inter-relacionam e apontam para a necessidade de localização nos territórios, aproximando as metas globais dos problemas locais de cada município (ONU, 2015), e isso só poderá ser alcançado por meio da educação.

Diante da abordagem apresentada, o objetivo desta pesquisa foi identificar a presença dos ODS nos PPCs de cursos de licenciatura em biologia da região amazônica paraense, além de caracterizar a abordagem que esses documentos fazem sobre a educação para a sustentabilidade.

2 EDUCAÇÃO PARA A SUSTENTABILIDADE NOS CURSOS DE LICENCIATURA EM BIOLOGIA

A formação inicial como preparação profissional tem papel crucial para possibilitar que os professores se apropriem de determinados conhecimentos e possam experimentar, em seu próprio processo de aprendizagem, o desenvolvimento de competências necessárias para atuar nesse novo cenário (BACCIN; DUTRA; COUTINHO, 2020). No caso dos licenciandos em ciências biológicas, o cenário de atuação é composto por esferas que perpassam desde a responsabilidade de atuar como profissional responsável pelo estudo e cuidado com as mais diversas formas de vida do planeta, bem como a de estar ligado diretamente à formação de cidadãos conscientes dos seus direitos, deveres e responsabilidades com o ambiente onde estão inseridos.

Nessa perspectiva, o ensino superior, em especial na área de licenciatura em biologia, possui a responsabilidade de contribuir fortemente com a formação da pluralidade de pessoas que venham a exercer funções de liderança em diversas áreas de atuação, bem como das que podem vir a trabalhar diretamente com a educação de outras pessoas.

Com isso, considera-se de extrema importância oferecer um ensino em uma perspectiva integrada e interdisciplinar, em que a sustentabilidade possa ser transversal nas diversas áreas do conhecimento. Isso porque, uma vez sensibilizados, esses alunos poderão trabalhar para a disseminação dos valores e da mudança de mentalidade na sociedade, contribuindo, dessa maneira, para um futuro ecologicamente viável (PETROVICH *et al.*, 2016).

A universidade nos tempos atuais deve se organizar para a formação de um profissional crítico e sua sensibilização com a realidade ambiental (STANQUEVISKI, 2019), além do compromisso com o ambiente em nível local, regional e global, que está estritamente relacionado com a atuação do professor de ciências e biologia. Esses profissionais precisam, portanto, desenvolver a sensibilidade de atuar com outros indivíduos em processos de formação e conscientização para o bem-estar e cuidados com a saúde do planeta.

Desse modo, com acesso aos princípios e abordagens da educação para a sustentabilidade, esses profissionais terão maiores subsídios na atuação contra descasos e desserviços governamentais e/ou de dirigentes de instituições onde irão atuar. Tal diligência pode fazer diferença no processo de ensino

e aprendizagem de outros indivíduos que somarão na luta pela melhoria e bem-estar do planeta como um todo.

Para Gadotti (2008a), educar para a sustentabilidade é, essencialmente, educar para uma vida sustentável, o que significa, entre outras coisas, educar para a simplicidade voluntária e para a quietude. Em corroboração, Antunes, Nascimento e Queiroz (2018) destacam que a educação para a sustentabilidade surge das necessidades de projetar novos rumos para problemas que afligem a sociedade, buscando refletir sobre as possibilidades que a educação apresenta para essas problemáticas, fomentando uma sociedade mais justa para as atuais e futuras gerações.

Compreende-se, dessa forma, que as universidades possuem grande relevância na reflexão, formação e difusão de novas concepções de desenvolvimento e sustentabilidade, participando da construção de outra cultura, atendendo, assim, aos anseios de sociedades mais justas, solidárias e ambientalmente sustentáveis (OLIVEIRA, 2017).

Responsável pela formação inicial e continuada de professores de ciências e biologia, assim como das demais áreas, as Instituições de Ensino Superior (IES), além de cumprir o seu papel como pessoa jurídica dentro de um ambiente físico, tem como missão e dever construir uma "consciência ambiental" nos futuros profissionais. Esse processo de conscientização contribuirá com a propícia capacidade humana em inverter a crescente degradação do meio ambiente e instaurar a sustentabilidade planetária (SILVA; BASTOS; PINHO, 2021).

Destaca-se, assim, a forte e importante influência que o ambiente institucional, somado à sua estrutura curricular, profissional e atitudinal perante a sociedade, possui na formação acadêmica e humana do indivíduo. Tudo isso contribui para as futuras ações que os profissionais em formação possam vir a desenvolver e que estejam ligadas às necessidades socioambientais do planeta, além de possíveis avanços e melhorias que esses futuros docentes poderão trazer como contribuição para a sociedade, o ambiente e o bem-estar em geral.

Nesse contexto, Ferreira e Gomes (2018) apontam que os ODS evidenciam um mecanismo conjugado de esforços e práticas cotidianas que podem promover o bem-estar das presentes gerações e a justiça intergeracional sem esquecer o bem-estar das gerações futuras.

Assim, ao se fazerem presentes na base formativa de novos profissionais da área de ciências biológicas, os ODS poderão compor, também, a trajetória de atuação profissional a ser percorrida por eles, agregando valores da educação para a sustentabilidade que são essenciais na tomada de consciência sobre as necessidades do planeta. Além disso, podem contribuir para a melhoria dos problemas socioambientais e para a harmonia da vida em todos os seus aspectos.

3 CAMINHO METODOLÓGICO

3.1 DELINEAMENTO DA PESQUISA

Esta pesquisa possui abordagens quantitativa e qualitativa, com procedimento metodológico baseado na análise documental, visto que esse tipo de pesquisa apresenta o objetivo de compreender uma dada realidade não em sua concretização imediata, mas de forma indireta, por meio da análise de documentos produzidos pelo homem a seu respeito (MENDES; FARIAS; NÓBREGA-THERRIEN, 2011).

Com essa abordagem, a pesquisa se divide em cinco fases: a) Delimitação do lócus de pesquisa; b) Pesquisa do PPC em sua publicação mais atual disponível em domínio público, no site da instituição; c) Construção de um instrumental de análise que possa refletir a abordagem que os documentos fazem sobre os ODS; d) Análise dos PPCs selecionados na fase "a", utilizando o instrumental construído na

fase “c”; e) Análise de dados relacionando à identificação de conceitos e ações ligadas à educação para a sustentabilidade presentes nos PPCs por meio da identificação dos ODS no instrumental.

3.2 LÓCUS DA PESQUISA

A Amazônia é conhecida por abrigar uma imensa diversidade biológica em seus ecossistemas. Porém, nas últimas décadas, tem sofrido os efeitos das mudanças climáticas e da ação antrópica de diversas formas, apresentando alterações profundas e talvez irreversíveis em seu bioma, o que, por sua amplitude, pode levar a impactos regionais, nacionais e globais (FERREIRA; VENTICINQUE; ALMEIDA, 2005).

Entre os estados brasileiros que formam esse ecossistema, o Pará é o segundo em extensão territorial, possuindo áreas de colonização mais recentes, como o sudeste do estado. Já as áreas de colonização mais antiga, tais como a Bragantina e o Baixo Tocantins, estão inseridas na mesorregião nordeste do estado (ALMEIDA, 2010).

Como lócus da pesquisa, foram escolhidas cinco IES localizadas na região amazônica paraense, seguindo os critérios de escolha: a) IES que ofertam o curso de licenciatura em biologia, ciências biológicas, ciências naturais com habilitação em biologia ou temáticas afins; b) O curso de biologia ofertado deve ter no mínimo cinco anos de criação; c) O campus da instituição deve estar localizado na região amazônica paraense.

Desse recorte de critérios, foram selecionados, para este estudo: 1) o curso de Licenciatura em Ciências Biológicas ofertado pelo Instituto Federal do Pará (IFPA) – Campus Abaetetuba; 2) o curso de Licenciatura em Ciências Biológicas ofertado pelo Instituto Federal do Pará (IFPA) – Campus Belém; 3) o curso de Licenciatura em Ciências Biológicas ofertado pela Universidade Federal do Pará (UFPA) – Campus Belém; 4) o curso de Ciências Naturais com habilitação em biologia ofertado pela Universidade Estadual do Pará (UEPA) – Campus Moju; e 5) o curso de Licenciatura em Ciências Biológicas ofertado pelo Instituto Federal do Pará (IFPA) – Campus Bragança (Figura 1).

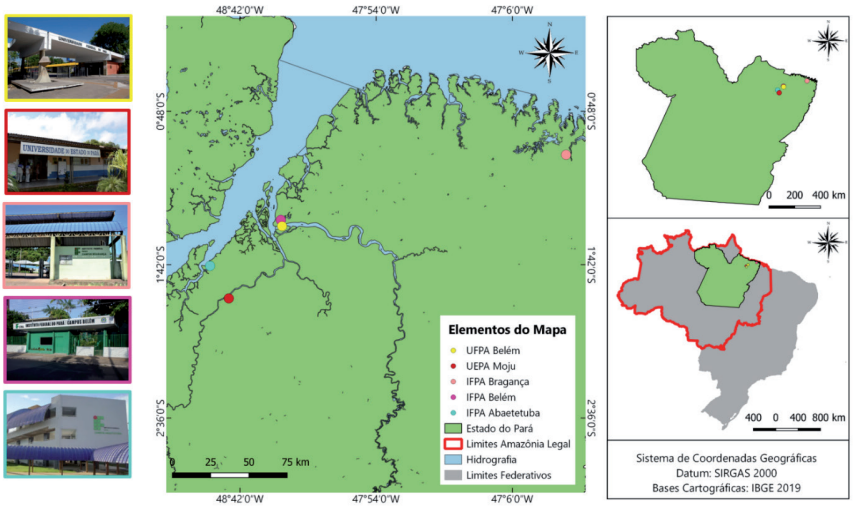

Figura 1 | Mapa de localização das instituições participantes da pesquisa.

Fonte: Produzido pelos autores (2022).

Como forma de preservar as identidades das instituições de ensino na tabulação, expressão e discussão dos resultados obtidos, os nomes das IES foram substituídos por siglas de forma aleatória no momento da escrita dos resultados como: IE1, IE2, IE3, IE4 e IE5.

3.3 INSTRUMENTO E OBJETOS DA PESQUISA

O instrumental utilizado na análise documental foi construído de forma que a análise favorecesse a identificação dos ODS nos documentos, a partir de temas que estão intimamente relacionados com a educação para a sustentabilidade. Tais instrumentos foram inspirados em metodologias já utilizadas por Castilho, Peña e Gil-Pérez (2021) e Lima (2020), em trabalhos com objetivos semelhantes.

O instrumental construído (Tabela 1) foi composto pela descrição de cada um dos 17 ODS, seguida do destaque de três palavras-chaves de busca para cada um deles. A escolha dessas palavras teve o objetivo de refletir a representatividade do ODS no documento analisado, por meio de um termo-chave característico do objetivo que estava sendo analisado naquele momento. Além disso, o instrumental apresenta uma descrição de temas contextualizados aos ODS e aos termos-chave de destaque, seguida das lacunas que eram preenchidas no momento da análise, quando foi verificada a presença, ausência e contexto em que o termo analisado aparece no documento (se presente).

Tabela 1 | Instrumental de análise dos Projetos Pedagógicos dos Cursos (PPCs) de licenciatura em ciências biológicas da região amazônica paraense.

Objetivos de Desenvolvimento Sustentável	*Termos-chave de busca*	*Temas contextualizados*	*PR**	*AU***	*Contexto usado*
01- Erradicação da pobreza	Pobreza Vulnerabilidade Erradicação	- Má distribuição de renda, riqueza e pobreza extrema; - Políticas públicas para pobres e vulneráveis e de combate à desigualdade.			
02- Fome zero e agricultura sustentável	Fome Segurança alimentar Agricultura sustentável	- Desperdício de alimentos; - Monocultura, transgênicos, pesticidas e inseticidas.			
03- Saúde e bem-estar	Saúde Bem-estar Expectativa de vida	- Doenças contagiosas, infecções sexualmente transmissíveis, transtornos mentais e dependência química; - Promoção da saúde.			
04- Educação de qualidade	Educação inclusiva Educação igualitária Ensino-aprendizagem	- Analfabetismo e fatores relacionados; - Discriminação relativa à diversidade cultural e desinteresse para com o patrimônio histórico e natural.			
05- Igualdade de gênero	Igualdade de gênero Empoderamento feminino Discriminação feminina	- Desigualdade de gênero e acesso a direitos; - Democracia do trabalho, direitos econômicos, equidade.			
06- Água potável e saneamento	Água potável Saneamento Recursos hídricos	- Desperdício e contaminação de água; - Água potável, reaproveitamento da água e saneamento básico.			

Objetivos de Desenvolvimento Sustentável	*Termos-chave de busca*	*Temas contextualizados*	*PR**	*AU***	*Contexto usado*
07- Energia limpa e acessível	Energias renováveis Energia acessível Eficiência energética	- Energia eólica, solar, de marés, geotérmica, hidráulica, etc.; - Economia de energia e recursos energéticos.			
08- Trabalho decente e crescimento econômico	Economia Desenvolvimento sustentável Empregabilidade	- Trabalho escravo, crise econômica (desemprego, baixos salários, inflação); - Agricultura de subsistência, trabalhos artesanais, gestão da pesca, turismo.			
09- Indústria, inovação e infraestrutura	Industrialização Infraestrutura sustentável Inovação industrial	- Construção sustentável (eficiência energética, redução e reutilização da água, tecnologias e materiais que não agridem o meio); - Gestão de resíduos, aproveitamento passivo dos recursos naturais, reutilização.			
10- Redução das desigualdades	Inclusão social Desigualdade social Políticas sociais	- Má distribuição de renda, riqueza e pobreza extrema, políticas públicas para pobres e vulneráveis; - Preconceitos (racismo, misoginia, LGBTfobia, xenofobia, etc.).			
11- Cidades e comunidades sustentáveis	Sustentabilidade urbana Patrimônio cultural Resiliência urbana	- Planejamento das cidades; - Construção sustentável, redução e reutilização da água, gestão de resíduos, aproveitamento passivo dos recursos naturais.			
12- Consumo e produção responsáveis	Gestão sustentável Recursos naturais Redução de resíduos	- Descarte e tratamento do lixo, reciclagem, reutilização, redução e reparação; - Emissão de gases de efeito estufa por queima de combustíveis fósseis e por carros.			
13- Ação contra a mudança global do clima	Mudanças climáticas Catástrofes ambientais Políticas ambientais	- Seca e escassez hídrica no mundo, inundações e enchentes; - Desastres naturais (incêndios, *tsunamis*, tempestades, tufões, tornados).			
14- Vida na água	Ecossistemas aquáticos Conservação da biodiversidade aquática Poluição aquática	- Aumento da temperatura e do nível do mar, poluição dos oceanos; - Perda de biodiversidade marinha.			

Objetivos de Desenvolvimento Sustentável	Termos-chave de busca	Temas contextualizados	PR*	AU**	Contexto usado
15- Vida terrestre	Ecossistemas terrestres	- Perda de biodiversidade marinha e terrestre, extinção e tráfico de espécies da fauna e flora; - Degradação de ecossistemas e biomas, relações ecológicas, serviços dos ecossistemas, ações de proteção e preservação do ambiente e reabilitação de espécies.			
	Biodiversidade				
	Conservação ambiental				
16- Paz, justiça e instituições eficazes	Justiça social	- Atuação cidadã e responsabilidade social; - Conflitos armados, insegurança (roubos, assaltos, assassinatos) e violência.			
	Sociedades pacíficas				
	Igualdade social				
17- Parcerias e meios de implementação	Globalização	- Relação e parceria no país e entre os países; - Avanços na ciência, tecnologia, economia, etc.			
	Transparência nas políticas públicas				
	Responsabilidade social				

**Presença de termo no documento analisado. **Ausência do termo no documento analisado.*
Fonte: Produzido pelos autores (2022).

3.4 COLETA E ANÁLISE DE DADOS

Foi realizado o *download* do PPC mais recente de cada um dos cursos selecionados para a pesquisa, diretamente do site oficial das instituições estudadas e salvo no formato PDF. A análise do PPC ocorreu de forma virtual, utilizando a ferramenta de busca do *Adobe Acrobat Reader* DC (ctrl + F) para localizar os termos-chave no documento.

Após análise, os dados foram tabulados em uma planilha do *Excel* 2017 considerando as categorias "presente", "ausente" e "contexto de uso", de acordo com o modo como o grupo de três termos-chave, considerados para cada ODS, ocorria no documento.

Com essas informações, o contexto dos termos pesquisados foi avaliado com base na análise de conteúdo que, segundo Santos (2012), é uma leitura "profunda", determinada pelas condições oferecidas pelo sistema linguístico, e objetiva a descoberta das relações existentes entre o conteúdo do discurso e os aspectos exteriores. Além disso, essa técnica permite a compreensão, utilização e aplicação de um determinado conteúdo, facilitando, assim, a interpretação da abordagem do tema educação para a sustentabilidade nos PPCs dos cursos analisados.

Ressalta-se que, naquele momento da análise, foi realizada a leitura completa do documento (PPC), porém, com ênfase e maior atenção nas partes em que os termos-chave eram localizados. Essa leitura faz parte do processo de análise de conteúdo, por meio da qual se buscou não somente a presença e/ou ausência do termo-chave no texto do documento, mas também seu sentido e contexto, interpretando seus significados na construção do PPC.

Além disso, foi realizada uma análise quantitativa dos dados, utilizando o programa estatístico Past versão 4.07b, para produzir um gráfico mostrando a frequência dos termos-chave que representam os ODS encontrados nos PPCs das instituições.

4 RESULTADOS E DISCUSSÃO

4.1 AFERIÇÕES GERAIS SOBRE A PRESENÇA DOS ODS NOS PPCS DOS CURSOS DE LICENCIATURA EM CIÊNCIAS BIOLÓGICAS DA REGIÃO AMAZÔNICA PARAENSE

A análise sobre a presença e/ou ausência de termos que remetem aos ODS nos PPCs dos cursos considerados nesta pesquisa mostrou que, das cinco instituições de ensino examinadas, os ODS 3, 4, 8, 15 e 16 foram encontrados em todos os PPCs. Em oposição, os ODS 5 e 11 não foram encontrados em nenhum dos documentos, e os ODS 10, 12 e 14 apareceram em 80% dos documentos analisados (Tabela 2).

Tabela 2 | Ocorrência dos ODS nos PPCs das instituições de ensino consideradas na pesquisa.

Objetivos de Desenvolvimento Sustentável (ODS)	*Instituições de Ensino Consideradas na Pesquisa*				
	EI1	EI2	EI3	EI4	EI5
1		X			
2		X			
3	X	X	X	X	X
4	X	X	X	X	X
5					
6		X	X	X	
7					X
8	X	X	X	X	X
9					X
10	X	X	X		X
11					
12	X	X	X	X	
13		X			X
14		X	X	X	X
15	X	X	X	X	X
16	X	X			X
17		X	X	X	X
Total	7	13	9	8	11

Fonte: Dados da pesquisa.

Ao expressar metas e princípios de determinado ODS, o documento que norteia o curso se mostra capaz de projetar novos avanços e melhorias, desde que bem orientados e pensados. Isso se dá em função de que a conexão empreendida pelos ODS reivindica esforços a favor da concreta superação

de mazelas que acometem a humanidade e o meio ambiente ao longo dos anos. Torna-se relevante, portanto, apontar que os propósitos centrais dos ODS se encontram em patente similitude com as dimensões da sustentabilidade (GOMES; FERREIRA, 2018).

Para Corrêa e Ashley (2018), a educação superior incorpora, comumente, a agenda de educação ambiental, sustentabilidade e desenvolvimento sustentável com as diversas interpretações e apropriações nos projetos pedagógicos, currículos, ementas dos componentes curriculares, nos documentos institucionais, nas falas do cotidiano, na formação docente e nos conteúdos e práticas de ensino e aprendizagem. No entanto, em muitos casos fica a sensação de que ainda não se tem maturidade de diálogo suficiente para que tais temas sejam entendidos.

Para uma análise mais aprofundada sobre o contexto que os PPCs das instituições trazem sobre os ODS, representa-se, na Figura 2, a frequência de termos correspondentes aos ODS que foram detectados em todos os PPCs (ODS 3, 4, 8, 15 e 16) das cinco instituições, verificando que as instituições IE3 e IE2 foram as que mais expressaram termos ligados a esses ODS em seus PPCs.

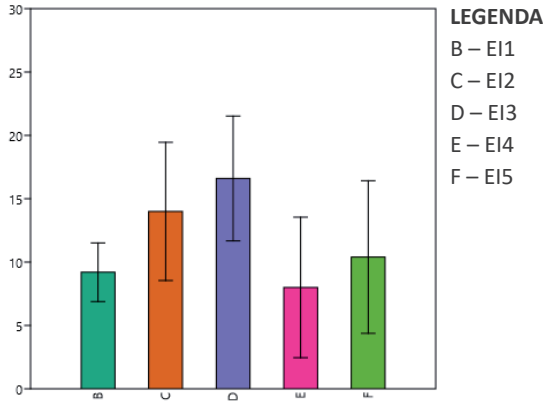

Figura 2 | Frequência dos termos-chave que representam os ODS detectados nas cinco instituições analisadas.

Fonte: Dados da pesquisa.

Salienta-se, a partir do gráfico, que a IE3 e a IE2, ao mostrarem expressiva frequência dos termos ligados aos ODS em questão, são destacadas como instituições preocupadas com temas como: saúde, bem-estar, responsabilidade social, educação de qualidade, condições trabalhistas e ecossistemas terrestres. Tal preocupação na formação inicial de futuros profissionais da área biológica está em comum acordo com os princípios da educação para a sustentabilidade.

Com isso, evidencia-se, por exemplo, que quando a IE2 afirma em seu PPC que "a formação dos seus futuros profissionais promove a compreensão do processo histórico que norteia a construção do conhecimento na área biológica, e sua importância para a sociedade através da educação, de vários aspectos de sua atuação sociopolítica e para a prática do desenvolvimento sustentável no país", mostra-se em clara conformidade com o ODS 4 (educação de qualidade). Assim, a instituição denota que o curso está comprometido com a construção de conhecimentos na área da biologia, cuja importância reside no desenvolvimento sustentável do país e da região onde ela está situada.

Ainda mediante a análise, foi perceptível verificar que as IE2 e IE3, por meio da considerável frequência de termos que remetem aos ODS 3, 4, 8, 15 e 16, mostram-se não apenas em conformidade com as perspectivas da educação para a sustentabilidade na formação dos seus profissionais, o que já seria de grande valia; mas preocupam-se, também, com a qualificação de seus futuros profissionais. Essa preocupação deriva do interesse que as referidas IES têm em formar cidadãos que respeitem e contribuam para o desenvolvimento sustentável da Amazônia, região onde os cursos são desenvolvidos e onde a maioria dos profissionais irão atuar depois de formados.

Nesse contexto, Guerra e Figueiredo (2014) chamam atenção para o fato de que a ambientalização curricular pode ser definida como um processo contínuo e dinâmico, voltado à formação de profissionais comprometidos com a busca permanente das melhores relações possíveis entre a sociedade e a natureza. Dessa forma, buscar a formação de profissionais envolvidos com os problemas sociais e ambientais da região configura um primeiro passo no processo contínuo de formação e apropriação de valores a serem considerados e trabalhados ao longo da vida do ser humano.

Em outros trechos, por exemplo, a IE3 afirma em seu PPC que o curso possui o objetivo de "interagir com as modernas abordagens e princípios do desenvolvimento sustentável relacionando o saber pedagógico com o saber biológico", além de "formar profissionais holísticos, críticos, autônomos e humanitários para o exercício da cidadania e da responsabilidade social".

Verifica-se, com isso, haver um contexto que se aproxima do ODS 8 (trabalho decente e crescimento econômico) e do ODS 17 (parcerias e meios de implementação), visto que a instituição busca uma formação voltada para o social, atendendo a princípios como responsabilidade social e humanística. Acredita-se, contudo, que esse tipo de formação deixa a desejar na abordagem ambiental, dado que ambas as abordagens (social e ambiental) merecem igual destaque e preocupação na formação de um profissional qualificado e responsável pelo bem-estar desta e das próximas gerações.

Ao buscar uma formação desse nível, as instituições estão de acordo com Freire (2007), que afirma que a crise global que vive a humanidade é resultado do nosso modo de vida e dos nossos valores coletivos e, por isso, pode-se considerá-la uma crise cultural. Todavia, a cultura desempenha um papel central na noção complexa de sustentabilidade em qualquer que seja a forma que toma no futuro, visto que depende das nossas decisões e das nossas ações em nível local.

É importante destacar, ainda, que todas as instituições abordam em seu PPC o ODS 4, que visa garantir o acesso à educação inclusiva e de qualidade. Recebe destaque a IE1, que objetiva "minimizar os efeitos das desigualdades sociais e regionais na permanência e conclusão da educação superior"; e a IE3, que objetiva "ter consciência da realidade em que vai atuar e da necessidade de se tornar agente transformador dessa realidade, na busca da melhoria da qualidade de vida da população humana, assumindo a sua responsabilidade na preservação da biodiversidade como patrimônio da humanidade".

Já com relação aos componentes curriculares que compõem os PPCs dos cursos e suas respectivas abordagens, percebe-se que nas IE2 e IE3 estão contempladas as diversas dimensões consideradas pela Agenda 2030 relativas às metas para os ODS (social, econômica, ambiental e institucional).

Os diversos eixos de componentes curriculares dentro do PPC constituem um fator positivo, em virtude de que a educação para a sustentabilidade não deve ser limitada a uma disciplina ou módulo dentro do curso, mas deve estar presente no curso por inteiro, desde em atividades de ensino (por meio das disciplinas, tanto da base comum quanto pedagógicas), até atividades de extensão e pesquisa. Nos documentos das demais instituições, foi possível observar a prevalência de certas dimensões, mas nunca as quatro em totalidade.

Dessa forma, a incorporação de temas relacionados aos princípios da educação para a sustentabilidade, no currículo da formação inicial, torna-se imprescindível no que tange ao processo de sensibilização e conscientização da comunidade acadêmica a respeito da importância da sustentabilidade ambiental. Esta, por sua vez, apresenta-se enquanto temática que deve permear a diversidade de disciplinas e práticas acadêmicas nas IES, podendo ser acompanhada de uma gestão adequada, com plena cooperação entre as diversas instâncias e órgãos institucionais e de acordo com as normas vigentes, envolvendo todos que dela fazem parte, como os funcionários, docentes e discentes (SANTOS, 2018).

De forma individualizada, é possível verificar que a IE5, embora aborde alguns termos constantes do instrumento de coleta, contextualiza esses termos de maneira vaga e superficial, não sendo possível

definir, de fato, sua importância para a instituição. Já as IE1, IE2, IE3 e IE4 parecem mais engajadas em expressar os conceitos que estejam relacionados e contextualizados com os ODS, mesmo não os citando diretamente nos documentos.

A IE2 se configurou, nesta pesquisa, como a instituição que mais aborda os conceitos, metas e princípios da educação para a sustentabilidade por meio da presença dos ODS em seu PPC. Isso ocorre não apenas por ter expressado 13 dos 17 ODS, mas também pela homogeneidade da abordagem desses princípios. Faz-se tal afirmação porque, desde a introdução do documento, passando pelos objetivos e ementas dos componentes curriculares do curso, perceberam-se elementos que remetem às metas dos ODS e estão conectados com o contexto destacado no instrumental de análise construído neste estudo.

Por conseguinte, repensar a formação inicial dos docentes de ciências e biologia em acordo com os ODS e na perspectiva da educação para a sustentabilidade deve ser prioritário em todas as IES. Essa ação pode contribuir para que esses futuros professores sejam capazes de reelaborar e ressignificar os espaços e as situações de aprendizagem no ambiente escolar, como também pode encorajá-los a participar da formação de equipes interdisciplinares na escola na temática de sustentabilidade (PETROVICH *et al.*, 2016).

Assim, entende-se que essa é uma medida que auxilia, de forma ativa, para que a comunidade escolar adote e priorize questões relacionadas com os princípios da educação para a sustentabilidade no ambiente educacional.

4.2 O QUE OS PPCS EXPRESSAM SOBRE A EDUCAÇÃO PARA A SUSTENTABILIDADE?

Pôde-se notar que em nenhum dos PPCs analisados havia, de maneira direta e explícita, a aplicação e contextualização do termo “educação para a sustentabilidade”. No entanto, identificou-se, com base no contexto dos ODS, expressões e trechos nos documentos que remetem aos princípios da educação para a sustentabilidade, o que permitiu reconhecer a consonância entre essa abordagem da sustentabilidade e os propósitos do curso por meio do seu PPC, ainda que de modo sutil.

Nessa perspectiva, Gadotti (2008a) destaca que educar para a sustentabilidade implica em mudanças no sistema e no respeito à vida, incluindo o cuidado diário com o planeta e com toda a comunidade. Com o sentido de educar para a vida, a IE4, por exemplo, enfatiza em seu PPC, no tópico de problemas centrais, que o egresso do curso deve estar apto a resolver alguns obstáculos, entre os quais cita o seguinte: “o professor de biologia deve empregar os conhecimentos biológicos para despertar o senso de responsabilidade social nos alunos da educação básica”.

Por conseguinte, percebe-se a grande responsabilidade dos profissionais que estão sendo formados em relação às suas funções. Isso porque, ao fazer parte da formação de cidadãos conscientes das suas responsabilidades sociais, tais profissionais serão responsáveis pelos cuidados e manutenção da vida no planeta, além de estarem em consonância com o ODS 16 (paz, justiça e instituições eficazes) e o ODS 17 (parcerias e meios de implementação).

A Unesco (2017) destaca, também, que a educação para a sustentabilidade fomenta a formação de cidadãos mais bem informados e dotados de novos valores, habilidades, atitudes e comportamentos, visando garantir a harmonia e o equilíbrio entre os processos sociais e ecológicos. Em conformidade, a IE2 deixa claro em seu PPC, no tópico sobre políticas de educação ambiental, que “o desenvolvimento sustentável é um dos valores que norteiam as ações da instituição, sendo fundamental para que esta atue de forma alinhada às questões sociais, ambientais e econômicas da atualidade, devendo ser amplamente difundido, a fim de fundamentar a formação de cidadãos críticos e conscientes de seu papel perante a sociedade”.

Contudo, verificou-se por meio da análise de conteúdo que, embora a instituição use o termo "desenvolvimento sustentável" no seu PPC, como mostra o trecho destacado acima, o conceito a ele empregado se associa mais aos princípios da educação para a sustentabilidade. Esse equívoco vem sendo considerado um dos recorrentes casos em que se confunde o uso das terminologias "desenvolvimento sustentável" e "educação para a sustentabilidade".

Efetivamente, a instituição preza pela formação de um cidadão crítico e consciente perante os problemas da sociedade, aspirando, com isso, que suas ações, depois de formado, possam refletir o tipo de formação recebida durante a graduação. Tal fato reflete um acordo com as metas do ODS 8 (trabalho decente e crescimento econômico) e com os princípios da educação para a sustentabilidade.

Além disso, sublinha-se o fato de os PPCs estarem preocupados em formar profissionais conscientes da sua responsabilidade com a diversidade biológica do planeta em níveis local e global. Entende-se, dessa maneira, que uma vez que a biodiversidade é essencial para a manutenção da vida na Terra, promover uma conscientização profissional a respeito de interferências no ambiente é necessário para a disseminação e execução dos princípios da educação para a sustentabilidade.

A educação de nível superior tem um papel prioritário na medida em que os futuros profissionais são aqueles que deverão trabalhar com os recursos sociais, ambientais e econômicos. Tais profissionais precisam, portanto, perceber sua função na busca por transformações sociais e melhoria de bem-estar para as pessoas das gerações atuais e das próximas (LOUREIRO; PEREIRA; PACHECO JÚNIOR, 2016).

Nessa perspectiva, a IE2, no tópico sobre competências gerais a serem desenvolvidas na formação do licenciado em ciências biológicas, considera importante "conduzir práticas educativas condizentes com a realidade e as possibilidades concretas da educação no processo da transformação social, visando o bem-estar coletivo", o que pode ser relacionado ao ODS 10 (redução das desigualdades). Desse modo, a instituição propõe aos seus discentes a possibilidade de mudanças comportamentais e formação social abrangentes, mostrando a essa comunidade perspectivas de atuação prática que favoreçam a coletividade e cuidados com o social e o ambiental.

Considerando a função social das instituições de ensino, frisa-se que a educação para a sustentabilidade compreende uma aprendizagem mais participativa, que cria vias de construção de conhecimentos mais contextualizados e, portanto, mais significativos. Com isso, considera-se a participação, a cocriação e a corresponsabilidade como aspectos centrais dessa abordagem, focando, assim, a importância dos processos coletivos, colaborativos e democráticos na busca por sociedades mais sustentáveis (GRANDISOLI *et al.*, 2020).

Acredita-se que os cursos de licenciatura em ciências biológicas devem propor aos seus educandos práticas de ensino e aprendizagem que despertem neles a vontade de transformar e fazer parte da sociedade, juntamente com os problemas que a envolvem. E que, diante desses problemas, possam pensar de forma crítica em soluções inovadoras e dentro dos princípios da sustentabilidade.

Tais ações podem ser visualizadas no PPC da IE4, no eixo temático de seres vivos e meio ambiente: "conhecer os principais problemas ambientais, tais como poluição, exploração de recursos naturais, mudanças globais, conservação e desenvolvimento". Esse aspecto faz parte dos deveres do profissional em formação, propendendo, com isso, à elucidação quanto ao enfrentamento que os futuros docentes terão na sua vida profissional. Destaca-se, com isso, que uma formação adequada poderá colaborar no sentido de apontar soluções para os problemas vividos.

Nesse contexto, Carletto e De Oliveira (2017) chamam atenção para o fato de que o professor, ator social e mediador da demanda de educandos para a sociedade, precisa discernir a problemática de seu setor, tendo em vista a finalidade educativa de sua função e, assim, assumir o seu papel, contribuindo para a formação integral dos cidadãos.

4.3 PERSPECTIVAS E POSSIBILIDADES PARA NOVOS CAMINHOS E ABORDAGENS

Apontar possibilidades de novos caminhos e perspectivas, que poderão ser adotados pelos cursos de ciências biológicas da Amazônia paraense, não significa, aqui, ditar regras ou uma receita pronta a ser seguida em um "passe de mágica". Significa, sim, expor percepções aferidas a partir do estudo realizado com os documentos norteadores de uma amostra de cursos da região, em intersecção com os ODS. Pretende-se, dessa forma, identificar possíveis efeitos e aplicações realizadas por uma ou outra instituição que, quando somadas, poderão apresentar resultados mais significativos com relação aos princípios aqui destacados.

Para Pereira *et al.* (2013), algumas mudanças são primordiais para criar uma sociedade mais sustentável, pois não há como manter a atual forma de consumo desenfreado, sendo necessário um repensar global, em busca de uma sociedade mais igualitária. Nesse sentido, o PPC da IE2 aponta que a estrutura curricular do curso deve "trabalhar no graduando uma formação identitária, holística, crítica, autônoma e humanitária, o conduzindo ao exercício da cidadania, ao respeito aos direitos humanos e à responsabilidade social que tem como um profissional de biologia". Com essa abordagem, é possível ter futuros profissionais preocupados com a igualdade social e conscientes do seu papel perante a sociedade e o planeta, podendo contribuir, de fato, para a melhoria e harmonia de ambos.

As universidades, portanto, como formadoras de corpo docente, devem fornecer uma habilitação consistente com o seu papel de agente de mudança do novo modelo de cidadania, exigido pela sociedade atual. Deve incluir, entre outros aspectos, a dimensão da sustentabilidade na formação dos seus discentes (ALARCÃO *et al.*, 2018).

Pensando nessa dimensão, a IE2 aponta, ainda, que o profissional egresso do curso de biologia deverá "ter consciência da realidade em que vai atuar e da necessidade de se tornar agente transformador dessa realidade". Essa abordagem está de acordo com a definição de sustentabilidade apresentada por Boff (2012), que remete o termo à preocupação da existência e manutenção dos recursos naturais com possibilidade de um ambiente propício para continuidade das gerações futuras. De maneira similar, mostra-se, também, alinhada aos ODS 14 (vida na água) e 15 (vida terrestre).

Não obstante, não será possível qualificar profissionais conscientes do seu papel enquanto pertencentes às dimensões da sustentabilidade se as instituições formadoras não previrem, em seus cursos, os princípios e metas norteadoras da educação para a sustentabilidade desde os documentos-base, reguladores do curso. Ao contrário, exigir tais princípios e metas deve funcionar como uma cadeia de efeitos, na qual os docentes do curso poderão dispor do documento como base para o desenvolvimento das suas atividades e, por sua vez, os discentes terão como base as dinâmicas, atividades e princípios disseminados pelos professores.

No PPC da IE1, por exemplo, a instituição objetiva "contribuir para a promoção da inclusão social pela educação", o que se relaciona com as metas do ODS 4 (educação de qualidade). Destacando, com esse instrumento, que a educação contribui de fato não somente para a inclusão social, mas para muitos outros princípios que são necessários para uma vida em coletividade, harmônica e sustentável.

Nesse sentido, Gadotti (2008b) considera que o alcance da cultura da sustentabilidade deve estar de acordo com o educar para pensar globalmente, para os sentimentos, para ensinar a identidade terrena, formar para a consciência planetária, para a compreensão, e educar para a simplicidade voluntária. Trata-se de um fazer pedagógico que passa, assim, da responsabilidade diluída para a ação concreta, compartilhada, praticando a sustentabilidade em todos os setores da sociedade.

Posto isso, espera-se que os princípios orientadores da educação para a sustentabilidade contribuam para essa mudança, a partir da educação, da governança e da mobilização da sociedade como um todo (GROHE; DA SILVA, 2022). Argumenta-se que é vital que instituições de ensino e comunidades passem por uma transição que as tornem engajadas na preservação do meio ambiente e no bem-estar das pessoas.

Nesse processo, o professor é um fator-chave e sua formação tem um efeito multiplicador, que deve ser reproduzido em sua futura carreira profissional (VARELA-LOSADA; ARIAS-CORREA; VEGA-MARCOTE, 2019). Educar para a sustentabilidade significa, nesse contexto, reconhecer o papel da educação tanto na conscientização sobre o impacto da organização social no ambiente, quanto na formação de sociedades preocupadas em diminuir esses impactos, de modo a estabelecer modelos sustentáveis de organização social (JACOBI; SULAIMAN, 2017).

Neste estudo, considera-se, portanto, a necessidade de os educadores refletirem sobre ações concretas em todos os níveis de ensino, para que se possa construir um futuro sustentável. Tal práxis deve elevar a importância do acesso a um conhecimento que resulte na discussão sobre a fragilidade ambiental diante da exploração desenfreada dos recursos do planeta, ao mesmo tempo que proponha ações práticas voltadas para a sua sustentabilidade (ARAÚJO, 2021). Essas medidas podem auxiliar os discentes de IES da Amazônia paraense a fazerem o mesmo, tornando o espaço educacional um ambiente ativo e preocupado com o bem-estar social e ambiental.

5 CONSIDERAÇÕES FINAIS

Ao identificar a limitada existência de estudos que investigam a abordagem que os PPCs de cursos de licenciatura em ciências biológicas fazem sobre os ODS e a educação para a sustentabilidade, este estudo dá sua contribuição na medida em que identifica e aponta a existência de uma abordagem que se relaciona com a agenda dos ODS, ainda que, algumas vezes, isso ocorra de modo indireto, fora de contexto ou sem aprofundamento.

Ao abordar os Objetivos de Desenvolvimento Sustentável em seu contexto de construção, desenvolvimento e execução, as instituições investigadas mostram-se atentas à perspectiva de novos rumos para a sociedade e para o planeta. Isso demonstra uma preocupação com a formação de novos profissionais e, consequentemente, com o planejamento para um planeta com uma humanidade que se preocupa com a manutenção da vida e dos direitos sociais e ambientais para as gerações atuais e futuras.

Foi possível identificar, também, que algumas instituições se mostram voltadas apenas para o crescimento e perspectivas sociais. Dedicam, assim, grande esforço e atenção do curso para a resolução de problemas que irão melhorar a qualidade de vida do ser humano, sem se atentar, por exemplo, para o fato de que essa melhoria depende diretamente do cuidado e atenção com o meio ambiente no qual esses indivíduos estão inseridos.

As contribuições desta pesquisa perpassam pelas dimensões: 1) prática, quando aponta uma das instituições como a que apresenta a abordagem mais completa sobre os princípios da educação para a sustentabilidade; 2) teórica, quando detalha a abordagem que os documentos norteadores dos cursos fazem sobre os ODS; e 3) social, quando contribui com apontamentos e possibilidades de caminhos para instituições que ofertam cursos superiores.

A primeira dimensão serve como norte para outras instituições em momentos de reformulação e/ou construção de seus PPCs, dispondo de orientações para que esses documentos apresentem equidade entre o que se espera da atuação de um profissional da área e os conceitos e princípios da educação para a sustentabilidade. A segunda dimensão traz uma visão geral de ações que os

seres humanos, por meio dos PPCs, possuem sobre seu papel no ambiente onde estão inseridos. E a terceira, a partir do apontamento de possibilidades e caminhos diversos, possibilita que os futuros profissionais sejam cada vez mais engajados e críticos diante das questões socioambientais.

Observa-se, como perspectivas futuras, a necessidade de atualização dos PPCs dos cursos de biologia não apenas em uma perspectiva temporal, dado o fato de alguns documentos serem recentes, mas como uma preocupação relativa aos conteúdos e às questões socioambientais, além da visão dos formandos sobre as necessidades de atuação de acordo com os princípios da educação para a sustentabilidade. Tal premissa imprime clareza e objetividade quanto a esses princípios na escrita dos documentos, facilitando, assim, o entendimento e o desenvolvimento das ações propostas pelos componentes pedagógicos do curso.

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Sustainable practices in cashew supply chains: a multi-case study in the scenario of small and medium-sized companies

Motivações e dificuldades para adoção de práticas sustentáveis nas cadeias de suprimentos do caju: um estudo de multicasos no cenário das pequenas e médias empresas

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ABSTRACT

This research analysed the motivation and difficulties behind adopting sustainable practices in small and medium-sized companies in the cashew industry supply chains (SMEs). The literature provides the main concepts of sustainable practices, motivation and difficulties in adopting practices in the context of SMEs. A multiple case study methodology was used. Two supply chains processing cashew nuts and cashew pulp in the state of Ceará were analysed. The implications of managing sustainability along the supply chain of SMEs, when they are still focal companies, lie in the fundamental importance of partnerships with research and business assistance organisations and the trust established with suppliers. To corroborate the research findings, the literature recognises that relationships are highly personal in SME supply chains.

Keywords: Sustainable practices. Motivations. Difficulties. Certification.

RESUMO

Esta pesquisa analisou quais são as motivações e dificuldades para a adoção de práticas sustentáveis nas cadeias de suprimentos de pequenas e médias empresas (PMEs) do setor do caju. Para tanto, a literatura apresenta os principais conceitos de práticas sustentáveis, motivações e dificuldades para

adoção de práticas no contexto de PMEs. A metodologia utilizada foi o estudo de caso múltiplo. Foram analisadas duas cadeias de suprimentos que atuam no beneficiamento de castanhas e polpa de caju no estado do Ceará. As implicações da gestão da sustentabilidade ao longo da cadeia de suprimentos de PMEs, quando estas são ainda empresas focais, recaem na fundamental importância de parcerias com organizações de pesquisa e de assistência de negócios, e da confiança estabelecida com os fornecedores. Corroborando os achados da pesquisa, a literatura aborda o reconhecimento de que, nas cadeias de suprimentos de PMEs, os relacionamentos são altamente pessoais.

Palavras-chave: Práticas sustentáveis. Motivações. Dificuldades. Certificação.

1 INTRODUCTION

One of the significant transformations that have been taking place in the landscape of organisations is associated with the development of management practices that strategically link the company´s values and concerns with social and environmental aspects and apply them to corporate business models (ASHBY, 2016; ASHBY; LEAT; HUDSON-SMITH, 2020). Thus, developing management models that consider sustainability a strategic factor leads companies to optimise resources, make legal adjustments and increase their capacity (PORTER; KRAMER, 2006; SANTOS, 2018).

However, developing social-environmental strategies and practices is challenging for many organisations and requires greater knowledge and integration of actors along their supply chains. In this way, the concept "Sustainability Management in Supply Chains (GSCS)" emerges and emphasises the development of strategies based on efficiency and responsibility, considering the dimensions of the *Triple Bottom Line* (BESKE; SEURING, 2014; PAGELL; WU, 2009).

In this way, one can observe that more and more companies are developing sustainability initiatives within and outside their organisational boundaries (SAEED; KERSTEN, 2019). Internally, businesses develop sustainable practices, understood in this paper as simple measures, such as process improvement, certification, waste management, etc. At the same time, these measures can be supported by stimuli that come from the supply chain itself with the vision of sharing changes in their production and consumption, from collaborative interactions with partners along the chain, which may come from suppliers or customers (INYAGA *et al.*, 2010; SANTOS, 2018; SILVA; FIGUEIREDO, 2020).

It is worth noting that most GSCS studies still focus on the perspective of large companies and their relationships in supply chains with a *top-down* approach (ASHBY *et al.*, 2012; TOUBOULIC; WALKER, 2015). However, other perspectives are equally important and should be explored empirically, as in the study of Small and Medium Enterprises (WALKER; JONES, 2012). In addition, there are already studies that indicate the contribution SMEs can make in the field of GSCS, especially concerning management guidance and supplier relationships (ASHBY; 2014; BATTISTI; PERRY, 2011; WALKER; JONES, 2012).

This perspective considers the importance of studying SMEs in the Brazilian scenario. In Brazil, SMEs represent approximately 98.5% of existing private organisations, accounting for 27% of the country´s GDP (SEBRAE, 2018). Furthermore, these companies stand out for their entrepreneurial potential (IBGE, 2018), as well as for the development of social capital, job creation, contribution to the decentralisation of economic activities and their potential for the incorporation or even generation of new product technologies and processes (NEVES *et al.*, 2011).

However, little is known about how Brazilian SMEs develop sustainability practices in their processes and supply chains (GHADGE *et al.*, 2020; NETO *et al.*, 2017; SCHMIDT *et al.*, 2018). According to Caldera *et al.* (2019), despite positive possibilities for social-environmental management of SMEs, there is still much to be studied regarding the practices adopted by such organisations and the motivation and difficulties faced by such companies and how they relate to other stakeholders.

Given the relevance of SMEs and the number of companies operating in the market, it becomes necessary to address how these small and medium-sized companies adopt sustainable practices, what motivates them to adopt such practices, and their consequences and difficulties. Although significant benefits of adopting these practices are usually perceived through waste reduction, energy savings, and employee retention, all along the chain, there is potential for innovation and new market opportunities (HONG; JEONG, 2018; PACHECO *et al.*, 2016).

Given this context, the problem that guided this research was: What are the motivations and difficulties for adopting sustainable practices in SME supply chains? To answer this question, the locus was SMEs in the food sector, specifically those that work with processing cashew nuts and pulp. Thus, the authors sought to highlight the specific characteristics of these companies and how they can influence the adoption of sustainable practices, both internally in their management processes and throughout their supply chains.

The choice of the food sector and, specifically, cashew farming is justified by the economic, social and environmental relevance it has in the northeast region of Brazil (AZEVEDO *et al.*, 2018; SILVA; PEREIRA; GOLD, 2018). Furthermore, the large cultivated area, especially in the states of Ceará, Piauí and Rio Grande do Norte, includes minority players, such as family farmers in production and SMEs and agricultural cooperatives that work in the processing and marketing of cashew nuts and pulp (ICB, 2020).

For these organisations, survival in the market comes according to the adaptations to the demands of their consumers and the pressures brought on by society (ASHBY, 2016; BATTISTI; PERRY, 2011; OLIVEIRA NETO *et al.*, 2022).

With this perspective in mind, the relevance of this proposed research is imperative in identifying peculiarities and better positioning Brazilian SMEs in the context of GSCS.

2 SUSTAINABLE PRACTICES, MOTIVATION AND DIFFICULTIES IN THE SME CONTEXT

The literature shows that SMEs increasingly seek to adopt sustainable practices in their internal and external processes (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016; OXBORROW; BRINDLEY, 2013). However, it becomes evident that there is no standard of the corporate social responsibility concepts applied by the different studies, especially from an environmental standpoint (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016; OXBORROW; BRINDLEY, 2013). Thus, sustainability management in SMEs is understood here as the management of sustainable practices collectively contemplating economic, environmental and social dimensions (BATTISTI; PERRY, 2011; HAHN; SCHEERMESSER, 2006; JOHNSON; SCHALTEGGER, 2016).

Thus, based on a review related to sustainable practices of SMEs, the most common methods adopted in companies' internal and external operations were identified. The vast majority mainly refer to environmental practices, and only some relate to social practices (NASCIMENTO; SILVA, 2020). Regarding external practices, it becomes necessary to understand that SMEs are not organised or structured in isolation. Most of them operate in supply chains where they are suppliers of other companies. Many sustainable practices can also occur beyond their internal operations, but usually within supply chains (relationships with the focal company in the chain or other suppliers) and in the markets in which they operate (competitors and partners).

In this sense, SMEs can establish strategic alliances to create networks of relationships to share knowledge (JOHNSON; SCHALTEGGER, 2016) and build partnerships with *stakeholders* (OXBORROW; BRINDLEY, 2013) to implement sustainable practices in their businesses (LEWIS *et al.*, 2015), and can also boost the implementation of sustainability management mechanisms (JOHNSON; SCHALTEGGER, 2016). In

addition, government partnerships strengthen relationships with Non-Governmental Organisations – NGOs and public entities – both seen as business opportunities (JOHNSON; SCHALTEGGER, 2016).

Regarding the motivation for the adoption of sustainable practices by SMEs, according to the literature, these are related to cost reduction (BATTISTI; PERRY, 2011; CASSELLS; LEWIS, 2011; OXBORROW; BRINDLEY, 2013; REVELL *et al.*, 2009), regulatory compliance (BATTISTI; PERRY, 2011; LEE, 2009; NETO *et al.*, 2017), reputation and improvement of the institutional image towards customers and competitors (DE BARCELLOS *et al.*, 2011; HALN; SCHEERMEN, 2005; REVELL *et al.*, 2009), improved relationship with *stakeholders* (JOHNSON; SCHALTEGGER, 2016) and customer pressures, also considering the focal companies of the supply chains in which SMEs are inserted (LEE, 2009). Another issue that emerges is the role that business managers and leaders assume as they are responsible for disseminating information, investing in values and decision-making in favour of sustainability (BATTISTI; PERRY, 2011; CASELS; LEWIS, 2011).

The literature also addresses the difficulties encountered in implementing sustainable practices in SMEs, thus hindering their engagement. For example, regarding the challenges faced by SMEs in implementing initiatives to seek sustainability, Jaramillo *et al.* (2019) identified, from a literature review, 175 obstacles distributed in different segments. The barriers that appeared most frequently were lack of financial resources, disbelief in benefits, lack of skilled labour, the high initial cost of implementing tools, lack of general information, lack of time, little or no internal awareness and external environmental issues, regulation, lack of funding and government incentives as well as little capacity for innovation and the high complexity of management tools.

The debate on Supply Chain Management (SCM) for SMEs is closely linked to the differences between small and large companies. When compared to large companies, SMEs differ in size and their management process, bringing important implications for how these companies manage their supply chain (COSTA *et al.*, 2010).

3 METHODOLOGY

This research has taken a qualitative approach to analyse the processes related to sustainable practices in supply chains. From this perspective, qualitative research has a descriptive character (GIL, 2017). Multiple case studies were used as a methodological strategy (YIN, 2010). This method was chosen for three reasons: more specifically, the case study allows for a detailed and in-depth analysis of the aspects that lead organisations to adopt sustainability practices and how this process takes place (considering positive and negative drivers). The choice is also complemented by the fact that few organisations still adopt such practices, which is still considered a recent phenomenon. Finally, multiple cases were chosen to generate comparability between companies in the same sector, to enrich the analyses and the consequent empirical-theoretical debate resulting from the research. Authors in the field of GSCS also reinforce the importance of the method in empirical studies in the context of SMEs (PAGELL; SCHEVCHENKO, 2014; REUTER *et al.*, 2010).

The selection of cases was based on identifying SMEs operating in the State of Ceará with some social-environmental management practices. This identification occurred through a *survey* applied in the sector. In this way, the authors sought to validate the information and contacts made through intermediate organisations. As a result, two organisations agreed to participate in the research, granting interviews and *on-site visits*.

The companies were contacted via e-mail and telephone with an explanation regarding the scope of the research, and appointments for visits were requested when allowed by the companies due to Covid-19 restrictions. The interviews were held between 2020 and 2021 with those responsible

for the organisations' management, operations, marketing and sustainability. Some interviews were conducted in person, others via *Google Meet.*

A total of 12 interviews were conducted, of which 4 interviewees were from case 1 and only 1 interviewee from case 2. Finally, 07 specific consultants from the Brazilian Support Service for Micro and Small Enterprises (Sebrae) and the Federation of Industries of Ceará (Fiec) who know the context of SMEs in research and foreign trade were also interviewed. In total, there are more than 15 hours of recordings, which were later transcribed and subjected to categorisation and analysis.

A semi-structured interview script was used, with open questions based on the theoretical concepts guiding this research. In addition, observations and documentary research were also used to corroborate and increase evidence from other sources (YIN, 2010) to complement the interviews and meet the criteria for validity and reliability.

It is important to note that a case study protocol was developed, describing the study categories and data correspondence. For ethical reasons and data security, the names of the companies studied were not mentioned in this article, only identified as case 1 and case 2. Obtaining approval from the University´s ethics committee was not necessary for this research.

4 CASE PRESENTATION, ANALYSIS AND DISCUSSION

This item describes the companies reflected in Case 1 and Case 2. Case 1 is a company that produces clarified juices and concentrate from tropical fruits for the food and beverage industry by using innovative processes that preserve functional characteristics and flavour while maintaining a high-quality standard. Case 2 is a company that positions differentiated products on the market, developed with the principle of guaranteeing identity and quality specifications, which are a consequence of effective control of raw materials, inputs and ingredients.

4.1 CASE 1

Case 1 is a small-sized company founded in 1999, producer of clarified and concentrate juices from tropical fruits, such as cashew apple, pineapple, *acerola* (aka Barbados cherry), banana, watermelon and melon. The company operates in B2B (*Business to Business*) and B2C (*Business to Consumer*) markets. The company has a competitive advantage in the cashew juice market by using tubular membranes to clarify the juice, allowing for greater efficiency and better preservation of some natural characteristics of the fruit, such as taste and smell. In addition, the company makes the product free from any contact with animal protein since the fruit clarification process in the domestic market is usually carried out through gelatin.

The company was founded on innovation principles and considers that innovation and sustainability are in its DNA. Proof of this is that the company was a pioneer in introducing to the market the first organic *cajuína* drink packaged in a can. The product is the result of a partnership with a large company and Embrapa Agroindústria Tropical (Fortaleza, CE), based on the use of microfiltration membrane technology, which allows for production on an industrial scale and the inclusion of the product at another market level. Furthermore, the company has invested in new markets, such as the production of cashew meat, for the vegan and vegetarian consumer markets. The company serves the domestic market, but as of 2018, it also started attending European markets by exporting clarified cashew juice.

4.1.1 SUSTAINABLE PRACTICES, MOTIVATION AND DIFFICULTIES

In the initial reports of the interviewees linked to the company, it was observed that the search for sustainability as a factor of competitiveness in the market is a hallmark of the company. However, as it is a small company, it suffers from some limitations imposed by the market, such as limited financial resources, lack of government initiative, quality labour, etc.

The company works with the main line of organic products and a secondary line of conventional products. In addition, it uses organic certification (*third party*) for clarified pulps and juices for sustainable production. Regarding food quality and safety criteria, the company has *Hazard Analysis and Critical Control Points* (HACCP) certification and a third certification specific to the norms that govern the orthodox Jewish Kosher diet.

For a small business, which does not have many resources and people who understand what sustainability is all about, certification serves as an instrumental guide in the adaptation processes and a better understanding of both practices and risk management for the business. In addition, external audits are seen as necessary, as they are assessments received, confirming that the processes comply with what is planned, as far as product specification is concerned and even in terms of how employees are treated.

According to the executive manager, the company adopts practices such as wastewater and atmospheric gas emissions treatment to mitigate the environmental impacts arising from the manufacture of products and the non-use of chemical products in cleaning and waste management remains of fruit peels and flesh. The waste is destined for the composition of animal feed distributed to partner farms in the region.

Also, according to the executive manager, some processes that depend on local government, such as waste management, end up interfering with some basic internal practices of the organisation. For example, according to the person responsible for the quality assurance sector, since the company does not require special garbage collection, they end up depending on public collection, which takes place twice a week, which often means accumulating garbage on the company premises. Another aspect that stands out is that there are no businesses related to selective waste collection and recycling that could be added as partners in the company's waste disposal chain.

Concerning external processes, according to the executive manager, the demands imposed on suppliers are closely linked to what customers demand. This brings us to the seminal works on sustainability in supply chains by Seuring and Muller (2008) and Beske and Seuring (2014). The authors state that companies usually pass on customer requirements to their suppliers, with several impositions, but mainly in the search for collaboration and further development of suppliers.

Regarding external practices, there is a requirement for specific certifications made to their suppliers, such as certification as an organic producer, HACCP and Kosher. Currently, the company is also looking for suppliers with Fair Trade practices, but it is challenging to find companies certified in producing tropical fruits.

With this issue in mind, case 1 posed an internal challenge in the search for FSSC 22000 certification (*Food Safety System Certification*), which offers a complete certification program, such as ISO 22000 and PRP (*Pre-Requirements Program*), specific to each sector, as well as HACCP. For the quality assurance director, risk management in the company can only be carried out more comprehensively through this certification process.

Regarding the questions that lead the focal company to adopt sustainable practices internally and throughout its supply chains, the interviewees listed some motivations, as the market encourages and drives them towards such changes. These changes give employees the strength to make the company

grow and meet the market's needs, ranging from implementing sustainability to becoming a new trend among healthy consumers concerned about what they consume.

The incentives of the focal company in adopting sustainable practices come, above all, from the customers. According to the quality assurance manager, innovation in the company's production process is one of the main reasons customers, especially *Business-to-Business*, work with the company. It is known, therefore, that there is an increasing demand for organic products in the international market, while there is great potential to increase the domestic consumer market. Therefore, certifications were essential to access these markets and seek competitiveness.

Good communication with the company's top management is supported by its international partners. In addition, given its structure, the company's flexibility allows the exploration of several products that larger companies do not serve because they are too big. This flexibility enables the company to explore product innovation based on demand by getting closer to its customers.

The company started testing the development of fruit juice pulp with a higher concentration of vitamin C, for example, using organic *acerola*, a fruit that has adapted quite well in the region and has good international market potential. Another initiative is related to fruit processing to utilise fruit's full potential.

When asked about the main difficulties and challenges for a sustainable business, the interviewees point out the high costs of organic production and the difficulty of gains in scale due to industrial capacity, which, consequently, affects competitiveness and insertion in the market with fair prices. Furthermore, while giving advantages to business, certification increases costs due to the need for an external audit and internal human resources for certification to be achieved. In addition, it also affects the product's attractiveness in the domestic market.

In parallel to the difficulties and challenges identified in the focal company, there are some related to suppliers along their supply chains, such as concerns regarding the awareness of human capital. In general, employees are simple people who have origins in the countryside and do not have specific knowledge about sustainable practices, their development within the organisation and how to correctly handle the product until it reaches the end consumer in a very competitive market.

4.2 CASE 2

Case 2 refers to a small company founded in 1992, which works with processing cashew nuts and producing some products derived from the cashew nuts, such as cashew cereal bars, cashew jam, and nut paste, among other products. The company was founded to produce cashew wine in the state of Ceará, but it had difficulties marketing the product and ended up specialising in the production of nuts and other fruit derivatives, such as fruit pulp.

The company serves the domestic market, including the state of Ceará and some states such as Rondônia, Pernambuco and Goiás. Its suppliers of basic inputs, such as cashew nuts, are from the surrounding regions of the municipality of Pacajus.

In the organisation's history, the support provided by the Incubator of the Instituto Centro de Ensino Tecnológico (Intece) was instrumental. The company also partnered with Embrapa CE, Senai CE and ITAL – Campinas-SP (Food Technology Institute) to improve their products.

4.2.1 SUSTAINABLE PRACTICES, MOTIVATION AND DIFFICULTIES

As the interview with the director advanced, it became clear that the company was built to process and commercialise cashew nuts and organised its internal practices along the supply chain based on quality and price criteria. However, it can be said that the company did not understand sustainability as a

factor of competitiveness in the market, but based on signals perceived from the market, the company began to seek a greater understanding of the subject.

When questioned about what leads the focal company to seek the adoption of sustainable practices along its supply chains, the general manager points out motivation related to market needs that end up driving changes in the company´s production processes, such as the adoption of good field practices. These requirements are passed on to employees and suppliers. These requirements range from the management of all waste produced within the organisation to the waste disposal process, this is an issue of sustainability, and the company seeks to involve all its business partners.

Considering that this is a small company with limited financial resources and because it does not have many human resources specialised in sustainability, the adoption of good practices in the field is its main guideline for sustainability applied to its business partners.

Concerning the main difficulties in implementing sustainable practices in the organisation and throughout the supply chain, the general manager reported that there is a difficulty in hiring qualified labour to perform these activities, and there is a lack of competitive market prices, fair prices that end up valuing the work of small-scale producers. As a result, Small and Medium Enterprises lack attractiveness to compete in the domestic market compared to competition with large companies in the city's industrial zone, in addition to lacking governmental incentives and the organisation's capital.

In parallel with the difficulties and challenges that suppliers face, there is a noticeable concern regarding the various demands for products demanded by customers and their requirements regarding the quality of the products offered.

4.3 ANALYSIS OF RESULTS

The analysis of the two organisations is based on existing differences and similarities. However, it becomes clear that the cases studied represent some very different realities regarding the inclusion of sustainability in companies and their supply chains. Although the literature presents a framework of practices used by SMEs around the world (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016), what became evident in these cases studied is that sustainability, even if it is seen as a strategic factor (as reported in Case 1), the practices are still very few when compared to other cases.

Specifically, regarding the results of Case 1, it is quite remarkable that the company was born out of an incubation program in partnership with recognised research funding institutions, such as Embrapa. In its essence, innovation and the search for market differentiation led to the execution of a collaboration with a large company to gain greater market competitiveness to solve a difficulty in its industrial capacity. Furthermore, sustainability practices in Case 1 are more focused on the requirement for organic product certification from their suppliers, as they result from pressures from the external consumer market.

In Case 2, the reality observed was different, with its practices focused on the conventional cashew nut market and without the existence of product certification. In the manager's perception, the company obtained its sustainability practices from the good practices in the field and when it comes to environmental licensing because the company has to fulfil several criteria that involve sustainability, always striving to provide better quality products to their consumers. The company operates in the domestic market, and its customers do not pressure the organisation to adopt such sustainable practices. However, the organisation has a vision that involves product innovation to serve foreign markets.

Many authors argue that what leads organisations to implement these sustainability practices in the company's internal environment, as well as in its supply chain, comes from incentives that come from their stakeholders, who are constantly seeking to gradually enhance these measures more efficiently within the organisation as well as external pressures imposed by consumers and government (DONATO *et al.*, 2016).

It is worth mentioning that in the context of the cases studied, the authors observed that Cases 1 and 2 are quite different regarding the implementation or execution of sustainable practices in their supply chains.

Therefore, Cases 1 and 2 reflect concerns regarding aspects that contemplate environmental issues in terms of sustainable practices that incorporate the search for new technologies that help minimise their organisations' environmental, social and economic impacts. Furthermore, in their production stages, they seek better efficiency in using their resources since they have certain difficulties in selecting certified suppliers (Case 1) compared to suppliers of products that demand organic resources (Case 2) when looking for suppliers who provide top-quality raw materials.

The main motivations regarding adopting sustainable practices reported by the organisations interviewed were reflected in their discourse. This understanding correlates with the theoretical findings of the research, as shown in Table 1.

Table 1 | Motivation for the adoption of sustainable practices by SMEs.

	Theory	*Case 1*	*Case 2*
Motivation	Cost reduction; Compliance with regulation; Reputation and improvement of the institutional image towards customers and suppliers; Improved relationships with Stakeholders; Customer pressures; Dissemination of information; Investment and decision-making in favour of sustainability. (Battisti; Perry, 2011; Cassells; Lewis, 2011; De Barcellos *et al.*, 2011; Haln; Scheermen, 2005; Johnson; Schaltegger, 2016; Neto *et al.*, 2017; Oxborrow; Brindley, 2013; Revell *et al.*, 2009)	Making a profit; Products with higher sustainable added value; Sustainability of the company and its balance; Raw material price; Sense of accomplishment and personal satisfaction; Proper disposal of waste; Search for excellence in having a cleaner process; Opening of the organic market; Acceptance of products by customers; Trust in suppliers; Partner customers; Fair price that covers costs; Better pay from another organisation.	Meet the desire of the consumer; Differentiated product in the market with quality and competitive differential; Good friendship; Quality product; Qualified for the market; Natural products.

Source: Made by the authors (2022).

When analysing the main difficulties for adopting sustainable practices in the companies that make up Case 1 and Case 2, we can highlight these difficulties in Table 2, where the main points raised in the interviews of the focal company are reported.

Table 2 | Difficulties in including sustainable practices by the focal company.

	Theory	*Case 1*	*Case 2*
Difficulties	Limited financial resources; Lack of qualified labour; High initial cost for implementing the tools (certification); Lack of information/ knowledge; Lack of government funding/ incentives; Complexity of management tools; Sustainable regulation. (Casalino *et al.* (2014); Cassells; Lewis (2011); Conway (2015); Conway *et al.* (2015); Esselaar *et al.* (2007); Fialho; Mota; Neutzling (2019); Ghazilla *et al.* (2015); Hasan (2016); Hjorth e Brem (2016); Ismail *et al.* (2011); Jaramillo *et al.* (2019); Jaramillo *et al.* (2019); Johnson; Schaltegger (2016); Lee (2009); Lewis *et al.* (2015); Oxborrow; Brindley (2013); Sulong *et al.* (2015); Tsalis *et al.* (2013))	Produce natural and organic product; Competitive market; Ideal product with quality; Ideal price practised in the market; Lower costs; Selection of suppliers; Feedstock; Organic certification; Lack of supervision; Qualified workforce; Quality of the product offered by the suppliers; Awareness of producers when it comes to sustainability; High costs to produce organic; Exploitation of prices of organic products; Field maintenance without pesticides; Very restrictive market; There is a lack of large industries with international standards in the North and Northeast regions; Competitiveness; Development of tests on products; Audit costs and expertise; Equipment maintenance.	Limited financial resources; Disbelief in the perceived benefit; Lack of skilled labour; Lack of information/ knowledge; Lack of awareness of environmental issues; Innovation Capacity; Lack of government funding/ incentives; Complexity of management tools; Sustainable regulation; Chestnut in the hands of brokers; Lack of sensitivity to the importance of producers' sustainability; Lack of knowledge about sustainability; Fair price in the chestnut; Diesel oil, gasoline and labour rising prices; Logistics.

Source: Made by the authors (2022).

According to the literature, when dealing with difficulties, we can find and corroborate the findings of the research for the implementation of sustainable practices in SMEs: difficulties such as lack of financial resources, disbelief in benefits, lack of qualified labour, high initial implementation costs of tools, lack of general information, lack of time, little or no internal and external awareness of sustainability issues, regulation, lack of government funding and incentives, little capacity for innovation and complexity of management tools (JARAMILLO *et al.*, 2019).

It is worth noting that disbelief in benefits is a common difficulty that prevents managers/owners from directing value and efforts toward sustainable issues (JOHNSON; SCHALTEGGER, 2016) because they do not believe in the financial returns and are sceptical about sustainable benefits (CONWAY, 2016, 2015).

As described in the literature, SME supply chains exercise sustainable practices and methods, even if this is a lot less when compared to large organisations (SPASESKI, 2014). From this perspective, it is possible to report the social practices that both companies presented in their interviews, emphasising the impacts that their organisations bring to the communities in which they are part, providing more income and appreciation of the human capital that is found in these communities, generating a better quality of life, encouraging local culture, thus establishing lasting relationships, based on trust. However, these sustainability practices, from the perspective of SMEs, are somewhat limited (ASHBU; HUDSON SMITH, 2018; BATTISTI; PERRY, 2011; COSTA *et al.*, 2010; GHADGE *et al.*, 2017; JOHNSON; SCHALTERGGER, 2015; KOBERG; LONGONI, 2019; KOT, 2018).

To better understand the lack of adoption of sustainable practices in the SMEs that were studied, a round of interviews was carried out with experts who support these SMEs. The analysis made by experts based on the context presented is that, in the cashew by-product supply chain, mainly comprised of cashew nuts, because it is a commodity, the issue of sustainability is not yet seen as a determinant to be more competitive in the market. However, as by-products (clarified juices, cashew nuts and cashew meat) start to stand out in the market, sustainability practices can indeed become a competitive factor. Thus, the adoption of practices is determined by the markets where these businesses operate.

Another point of view is that there are incentives provided by the government of the state of Ceará, but these do not serve the entire category of SMEs, specifically sustainability projects, where targeted investments are a challenge.

The implications of sustainability management along the supply chain of Small and Medium Enterprises when these are still focal companies lie in the fundamental importance of partnerships with research and business assistance organisations and the trust established with suppliers (COSTA *et al.*, 2010; KOBERG; LONGONI, 2019). As far as research is concerned, the work with Embrapa, Senai, Sebrae and research and consultancy services linked to universities becomes instrumental. Corroborating with research findings, the literature addresses the existence of recognition that in SME supply chains, relationships are highly personal (ASHBY; HUDSON SMITH, 2018).

5 CONCLUSION AND RECOMMENDATIONS

The companies studied in this research fit the requirements of Small and Medium Enterprises according to Sebrae (Brazilian Micro and Small Business Support Service). Small and medium-sized companies are inclined to develop sustainable practices due to the demands from legislation or when the market requires such practices, confirming the survey carried out by Sebrae with entrepreneurs who are predisposed to such practices in their organisations, contemplating the 2012 United Nations Conference on Sustainable Development (SEBRAE, 2012). For organisations to develop and put sustainability into practice, industries tend to increase their practices with simple measures that involve sustainability.

Given the results, it is clear that companies have different levels of understanding of what sustainability is, with knowledge, perceptions and needs of different markets throughout the existence of each organisation.

The two cases analysed present similar realities due to the sector of activity and structure of the supply chain, but they are different in executing their activities aimed at sustainability practices. Concerning these practices, in Case 1, the evidence shows that the company has its practices geared towards the export sector, with specific requirements for the certification of organic products, as well as other

certification needs, which leads to suppliers having to fulfil several requirements that contemplate sustainability in its supply chain. On the other hand, in Case 2, sustainability practices focus on activities that contemplate the products' quality to consumers.

The survey results indicate the need for more thorough studies to integrate sustainability and supply chain issues. To achieve a GSCS, changes are needed in paradigms that contemplate sustainability in organisations, as well as ways to stop being seen as a cost for organisations and start to represent a potential source of competitive market advantage.

The research presents as its main contribution the evidence of sustainability practices and the description of the motivators of SMEs to have attitudes that contemplate the adoption of sustainable practices. On the other hand, it is observed that the challenges that companies face in the adoption of such practices are affected by the lack of resources of the organisations, which results in few investments in technologies, manpower and knowledge for the implementation of sustainability, which is expanded with the lack of incentives on the part of the public power to address such gaps.

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Motivações e dificuldades para adoção de práticas sustentáveis nas cadeias de suprimentos do caju: um estudo de multicasos no cenário das pequenas e médias empresas

Sustainable practices in cashew supply chains: a multi-case study in the scenario of small and medium-sized companies

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RESUMO

Esta pesquisa analisou quais são as motivações e dificuldades para a adoção de práticas sustentáveis nas cadeias de suprimentos de pequenas e médias empresas (PMEs) do setor do caju. Para tanto, a literatura apresenta os principais conceitos de práticas sustentáveis, motivações e dificuldades para adoção de práticas no contexto de PMEs. A metodologia utilizada foi o estudo de caso múltiplo. Foram analisadas duas cadeias de suprimentos que atuam no beneficiamento de castanhas e polpa de caju no estado do Ceará. As implicações da gestão da sustentabilidade ao longo da cadeia de suprimentos de PMEs, quando estas são ainda empresas focais, recaem na fundamental importância de parcerias com organizações de pesquisa e de assistência de negócios, e da confiança estabelecida com os fornecedores. Corroborando os achados da pesquisa, a literatura aborda o reconhecimento de que nas cadeias de suprimentos de PMEs, os relacionamentos são altamente pessoais.

Palavras-chave: Práticas sustentáveis. Motivações. Dificuldades. Certificação.

ABSTRACT

This research analysed the motivation and difficulties behind adopting sustainable practices in small and medium-sized companies in the cashew industry supply chains (SMEs). The literature provides the main concepts of sustainable practices, motivation and difficulties in adopting practices in the context of SMEs. A multiple case study methodology was used. Two supply chains processing cashew nuts and cashew pulp in the state of Ceará were analysed. The implications of managing sustainability along the supply chain of SMEs, when they are still focal companies, lie in the fundamental importance of partnerships with research and business assistance organisations and the trust established with suppliers. To corroborate the research findings, the literature recognises that relationships are highly personal in SME supply chains.

Keywords: Sustainable practices. Motivations. Difficulties. Certification.

1 INTRODUÇÃO

Uma das importantes transformações que vêm ocorrendo no ambiente organizacional está associada ao desenvolvimento de formas de gestão que se apropriem de valores e preocupações com aspectos sociais e ambientais de forma estratégica, e os apliquem aos modelos de negócios corporativos (ASHBY, 2016; ASHBY; LEAT; HUDSON-SMITH, 2020). Assim, desenvolver modelos de gestão que considerem a sustentabilidade como um fator estratégico leva as empresas à otimização de recursos, adequações legais e aumento das capacidades (PORTER; KRAMER, 2006; SANTOS, 2018).

Contudo, o desenvolvimento de estratégias e práticas socioambientais é desafiador para as organizações e requer um maior conhecimento e integração de atores ao longo das suas cadeias de suprimento. Dessa forma, surge o conceito "Gestão da Sustentabilidade em Cadeias de Suprimento (GSCS)", que enfatiza o desenvolvimento de estratégias baseadas na eficiência e responsabilidade, considerando as dimensões do *Triple Bottom Line* (BESKE; SEURING, 2014; PAGELL; WU, 2009).

Assim, observa-se que as empresas passam a desenvolver iniciativas de sustentabilidade dentro e fora dos seus limites organizacionais (SAEED, KERSTEN, 2019). Internamente, os negócios desenvolvem práticas sustentáveis, entendidas nesse trabalho como ações cotidianas, como, por exemplo, melhoria de processos, certificações, gestão de resíduos, etc. Paralelamente, essas ações podem ser reforçadas quando existem estímulos que vêm da cadeia de suprimentos numa perspectiva de compartilhar mudanças na sua produção e consumo, a partir das interações colaborativas com os parceiros da cadeia, podendo ser fornecedores ou clientes (NYAGA, *et al.*, 2010; SANTOS, 2018; SILVA; FIGUEIREDO, 2020).

Vale salientar que grande parte dos estudos em GSCS ainda se foca na ótica das grandes empresas e seus relacionamentos nas cadeias de suprimentos, com uma abordagem *topdown*, na maioria das vezes (ASHBY *et al.*, 2012; TOUBOULIC; WALKER, 2015). No entanto, é notável que outras perspectivas também sejam importantes e devem ser exploradas empiricamente, como é o caso do estudo de Pequenas e Médias empresas (WALKER; JONES, 2012). Já existem estudos que indicam a contribuição que PMEs podem apresentar no campo da GSCS, principalmente no que se refere à orientação de gestão e relacionamentos com fornecedores (ASHBY; 2014; BATTISTI; PERRY, 2011; WALKER; JONES, 2012).

Nessa perspectiva, observa-se a importância de estudar as PMEs no cenário brasileiro. No Brasil, as PMEs representam aproximadamente 98,5% dos estabelecimentos privados existentes, respondendo por 27% do PIB (SEBRAE, 2018). Essas empresas também se destacam pelo seu potencial empreendedor (IBGE, 2018), além do desenvolvimento de capital social, geração de empregos, contribuição para a descentralização de atividades econômicas e potencial de assimilação ou, até mesmo, geração de novas tecnologias de produtos e processos (NEVES *et al.*, 2011).

Contudo, quando se aplica um olhar para como as PMEs no Brasil desenvolvem práticas de sustentabilidade nos seus processos e também ao longo das suas cadeias de suprimentos, pouco é

sabido (GHADGE *et al.*, 2020; NETO *et al.*, 2017; SCHMIDT *et al.*, 2018). Segundo Caldera *et al.* (2019), apesar das possibilidades positivas com relação à gestão socioambiental das PMEs, há muito ainda a ser estudado no que tange às práticas adotadas, às motivações e às dificuldades enfrentadas por tais empresas e como elas se relacionam com outros *stakeholders*.

Dada a relevância das PMEs em números de empresas atuantes no mercado, faz-se necessário abordar a forma como essas pequenas e médias empresas acabam gerenciando essa adoção de práticas sustentáveis em suas organizações, bem como o que as motivam a adotar tais práticas e suas dificuldades, já que se percebem os benefícios significativos com a adoção dessas práticas, por meio da redução de resíduos, economia de energia, retenção de funcionários, e, ao longo da cadeia, pelo potencial de inovação e novas oportunidades de mercado (HONG; JEONG, 2018; PACHECO *et al.*, 2016).

Diante dessa contextualização, a problemática que norteou esta pesquisa foi: Quais são as motivações e dificuldades para a adoção de práticas sustentáveis nas cadeias de suprimentos de PMEs? Para responder a essa questão, o *loco* de pesquisa foi PMEs do setor de alimentos, mais especificamente aquelas que atuam no beneficiamento de castanhas e polpa de caju. Assim, buscou-se evidenciar as características específicas dessas empresas e como podem influenciar a adoção de práticas sustentáveis, tanto internamente nos seus processos de gestão como ao longo das suas cadeias de suprimentos.

A escolha do setor de alimentos e, especificamente, a cajucultura, se justifica pela relevância econômica, social e ambiental que possui na Região Nordeste do Brasil (AZEVEDO *et al.*, 2018; SILVA; PEREIRA; GOLD, 2018). A ampla área cultivada, especialmente nos estados do Ceará, Piauí e Rio Grande do Norte, agrega atores minoritários, como agricultores familiares na produção, e PMEs e cooperativas agrícolas que atuam no beneficiamento e comercialização da castanha e polpa de caju (ICB, 2020).

Para essas organizações, a sobrevivência no mercado está de acordo com as adaptações das exigências de seus consumidores e as pressões interpostas pela sociedade (ASHBY, 2016; BATTISTI; PERRY, 2011; OLIVEIRA NETO *et al.*, 2022).

Com essa perspectiva, demonstra-se a relevância deste tipo de pesquisa proposto, no sentido de identificar peculiaridades e melhor posicionar as PMEs brasileiras no contexto de GSCS.

2 PRÁTICAS SUSTENTÁVEIS, MOTIVAÇÕES E DIFICULDADES NO CONTEXTO DAS PMEs

A literatura mostra que as PMEs buscam adotar, cada vez mais, práticas sustentáveis nos seus processos internos e externos (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016; OXBORROW; BRINDLEY, 2013). Contudo, observa-se que não há um padrão de conceitos em que os estudos são aplicados, especialmente na perspectiva ambiental, da responsabilidade social corporativa (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016; OXBORROW; BRINDLEY, 2013). Dessa forma, o conceito de gestão da sustentabilidade em PMEs aqui é entendido como a gestão de práticas sustentáveis contemplando as dimensões econômica, ambiental e social, coletivamente (BATTISTI; PERRY, 2011; HAHN; SCHEERMESSER, 2006; JOHNSON; SCHALTEGGER, 2016).

Assim, com base na revisão de pesquisas relacionadas às práticas sustentáveis das PMEs, identificaram-se as práticas mais comuns adotadas nas operações internas e externas das empresas. Observa-se que a maioria se refere a práticas ambientais, e somente algumas delas estão relacionadas a práticas sociais (NASCIMENTO; SILVA, 2020). Sobre as práticas externas, é necessário compreender que as PMEs não se organizam nem se estruturam isoladamente. A maioria atua em cadeias de suprimento que são fornecedoras de outras empresas. Muitas das práticas sustentáveis podem ocorrer também para além de suas operações internas, mas nas cadeias de suprimentos (relações com empresa focal da cadeia, ou outros fornecedores) e nos mercados em que atuam (concorrentes e parceiros).

Nesse sentido, as PMEs podem atuar em alianças estratégicas a fim de criar redes de relacionamentos para compartilhar conhecimentos (JOHNSON; SCHALTEGGER, 2016) e criar parcerias com *stakeholders* (OXBORROW; BRINDLEY, 2013) no intuito de implementar práticas sustentáveis nos seus negócios (LEWIS *et al.*, 2015), e impulsionar também a implementação de mecanismos de gestão de sustentabilidade (JOHNSON; SCHALTEGGER, 2016). As parcerias governamentais aludem ao estreitamento das relações com as Organizações Não Governamentais – ONGs e entidades públicas, sendo ambos vistos como oportunidades de negócios (JOHNSON; SCHALTEGGER, 2016).

Com relação à motivação para a adoção de práticas sustentáveis por PMEs, de acordo com a literatura, essas são relacionadas à redução de custos (BATTISTI; PERRY, 2011; CASSELLS; LEWIS, 2011; OXBORROW; BRINDLEY, 2013; REVELL *et al.*, 2009), cumprimento da regulamentação (BATTISTI; PERRY, 2011; LEE, 2009; NETO *et al.*, 2017), reputação e melhoria da imagem institucional perante os clientes e os concorrentes (DE BARCELLOS *et al.*, 2011; HALN; SCHEERMEN, 2005; REVELL *et al.*, 2009), melhoria do relacionamento com os *stakeholders* (JOHNSON; SCHALTEGGER, 2016) e pressões de clientes, considerando também as empresas focais das cadeias de suprimentos nas quais as PMEs estão inseridas (LEE, 2009). Outra questão que emerge é o papel que os gestores e líderes dos negócios assumem por serem os responsáveis pela disseminação de informações, investimentos em valores e tomadas de decisão em favor da sustentabilidade (BATTISTI; PERRY, 2011; CASSELS; LEWIS, 2011).

A literatura também trata das dificuldades encontradas na implementação de práticas sustentáveis nas PMEs, dificultando, assim, o seu engajamento. Sobre as dificuldades das PMEs para implementação de iniciativas para a busca da sustentabilidade, Jaramillo *et al.* (2019) identificaram, a partir de uma revisão da literatura, 175 obstáculos distribuídos em diversos segmentos. Os obstáculos que apareceram com maior frequência foram a falta de recursos financeiros, descrença dos benefícios, falta de mão de obra qualificada, alto custo inicial para implementação de ferramentas, falta de informações gerais, falta de tempo, pouca ou nenhuma consciência interna e externa das questões ambientais, regulamentação, falta de financiamento e incentivos governamentais, pouca capacidade de inovação e complexidade das ferramentas de gestão.

O debate sobre a Gestão da Cadeia de Suprimentos (GCS) para as PMEs está estreitamente ligado às diferenças entre as pequenas e grandes empresas. As PMEs, quando comparadas com as empresas de grande porte, não diferem somente com relação ao seu tamanho, mas também no processo de gerenciamento, trazendo implicações importantes sobre como essas empresas orientam sua cadeia de suprimentos (COSTA *et al.*, 2010).

3 METODOLOGIA

Visando analisar os processos relacionados às práticas sustentáveis de cadeias de suprimentos, esta pesquisa apresenta-se como de natureza qualitativa. Nessa perspectiva, a pesquisa qualitativa teve seu caráter descritivo (GIL, 2017). Como estratégia metodológica, foi utilizado o estudo de caso múltiplo (YIN, 2010). A escolha desse método se dá por três razões: especificamente o estudo de caso permite uma análise detalhada e profunda sobre os aspectos que levam as organizações a adotarem práticas de sustentabilidade e como se dá esse processo (considerando direcionadores positivos e negativos para tal). A escolha é também complementada pelo fato de ainda haver poucas organizações que adotam tais práticas, sendo considerado ainda um fenômeno recente. Por fim, escolheu-se o caso múltiplo com o objetivo de gerar comparabilidade entre empresas de um mesmo setor, a fim de enriquecer as análises e o consequente debate empírico-teórico resultante da pesquisa. Autores da área de GSCS também reforçam a importância do método em estudos empíricos no contexto de PMEs (PAGELL; SCHEVCHENKO, 2014; REUTER *et al.*, 2010).

A seleção dos casos se deu a partir da identificação de PMEs atuantes no estado do Ceará e que possuíam algum tipo de práticas de gestão socioambiental. Essa identificação ocorreu por meio de uma pesquisa *survey* aplicada no setor. Dessa forma, buscou-se validar as informações e por meio de organizações

mediadoras os contatos foram feitos. Duas organizações aceitaram participar da pesquisa, concedendo entrevistas e visitas *in loco*.

O meio de contato com as empresas foi via e-mail e telefone, explicando assim o escopo da pesquisa e solicitando agendamento de visitas quando permitidas pelas empresas devido às restrições da Covid-19. As entrevistas foram aplicadas entre os anos de 2020 e 2021 com responsáveis de gestão, operações, comercialização e sustentabilidade das organizações. Algumas entrevistas foram conduzidas presencialmente, outras via ferramenta do *Google Meet*.

Um total de 12 entrevistas foram conduzidas, dessas, quatro entrevistados são referentes ao Caso 1, e apenas um entrevistado é referente ao Caso 2, por fim, foram entrevistados também sete consultores específicos conhecedores do contexto de PMEs, nas áreas de pesquisa e comércio exterior, do Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (Sebrae) e da Federação das Indústrias do Ceará (Fiec). No total, são mais de 15 horas de gravação, que posteriormente foram transcritas e submetidas à categorização e análise.

Um roteiro de entrevista semiestruturada, contendo questões abertas com base nos conceitos teóricos norteadores desta pesquisa, foi utilizado. Também foram utilizadas observações e pesquisa documental para corroborar e aumentar a evidência de outras fontes (YIN, 2010), de modo a complementar as entrevistas e atender aos critérios de validade e confiabilidade.

Importante ressaltar que foi desenvolvido um protocolo de estudo de caso, com descrição das categorias do estudo e a correspondência aos dados. Por questões éticas e para a segurança dos dados, os nomes das empresas estudadas não foram citados no presente artigo, sendo identificadas como Caso 1 e Caso 2. Vale ressaltar que a presente pesquisa não precisou passar pelo Comitê de Ética da universidade.

4 APRESENTAÇÃO DOS CASOS, ANÁLISES E DISCUSSÃO

Neste item são descritas as empresas do Caso 1 e Caso 2. O Caso 1 é uma empresa produtora de sucos clarificados e polposos de frutas tropicais para a indústria de bebidas e alimentos com processos inovadores que preservam características funcionais e sabor, e proporcionam alto padrão de qualidade. Já o Caso 2 é uma empresa que coloca no mercado produtos diferenciados, desenvolvidos com o princípio de garantir as especificações de identidade e qualidade, as quais são consequências de um controle efetivo de matéria-prima, insumos e ingredientes.

4.1 CASO 1

O Caso 1 é uma empresa de pequeno porte fundada em 1999, produtora de sucos clarificados e polposos de frutas tropicais, como caju, abacaxi, acerola, banana, melancia e melão. A empresa atua tanto nos mercados B2B (*Business to Business*) quanto B2C (*Business to Consumer*). A empresa tem como diferencial competitivo no mercado do suco de caju a utilização de membranas tubulares para clarificação do suco, permitindo uma maior eficiência e a melhor preservação de algumas características naturais da fruta, como gosto e cheiro. Além disso, a empresa torna o produto livre de qualquer contato com proteína animal, uma vez que o processo de clarificação de frutas no mercado doméstico é realizado usualmente por meio de gelatina.

A empresa nasceu com auxílio de editais de inovação e considera que possui em seu DNA a inovação e a sustentabilidade, prova disso é que ela foi pioneira em apresentar ao mercado a primeira cajuína orgânica embalada em lata. O produto é resultado de uma parceria com uma empresa de grande porte e a Embrapa Agroindústria Tropical (Fortaleza, CE), a partir do uso da tecnologia de membranas de microfiltração, o que permitiu a produção em escala produtiva industrial e a inserção do produto

em outro patamar de mercado. Além disso, tem investido em novos mercados, como, por exemplo, a produção de carne de caju para consumidores veganos e vegetarianos. A empresa atende o mercado doméstico, mas a partir de 2018 passou também a atender mercados na Europa, exportando suco clarificado de caju.

4.1.1 PRÁTICAS SUSTENTÁVEIS, MOTIVAÇÕES E DIFICULDADES

Nos relatos iniciais dos entrevistados ligados à empresa observou-se que a busca pela sustentabilidade como um fator de competitividade no mercado é uma marca da empresa. Porém, por ser uma pequena empresa, sofre com algumas limitações impostas no mercado, como recursos financeiros limitados, falta de iniciativa por parte do governo, mão de obra de qualidade, etc.

A empresa trabalha com a linha principal de produtos orgânicos e uma linha secundária de produtos convencionais. Com relação à produção sustentável, vale-se da certificação orgânica (certificação *third party*) nas polpas e sucos clarificados. Com relação aos critérios de qualidade e segurança de alimentos, possui o *Hazard Analysis and Critical Control Point* (Haccop) e uma terceira certificação, específica às normas que regem a dieta judaica ortodoxa, a Certificação *Kosher*.

Para uma empresa de pequeno porte, que não possui muitos recursos e pessoas que entendam o que é sustentabilidade, as certificações servem como guias essenciais nos processos de adequação, melhor entendimento das práticas e gestão de riscos para o negócio. As auditorias externas são vistas como importantes, pois são avaliações recebidas de que os processos estão em concordância com o que é previsto, nos aspectos processuais, do produto, e até mesmo no tratamento com os colaboradores.

De acordo com o gerente-executivo, a empresa adota práticas como: estação de tratamento da água e emissões de gases atmosféricos, como forma de mitigar os impactos ambientais oriundos da fabricação dos produtos; e a não utilização de produtos químicos na limpeza e gestão de resíduos, restos de cascas e bagaço das frutas. Os resíduos são destinados à composição de ração animal distribuída para fazendas parceiras da região.

Ainda segundo o gerente-executivo, alguns processos que dependem do poder público local, como a gestão do lixo, acabam interferindo em algumas práticas básicas internas da organização. De acordo com o responsável do setor de qualidade, por não necessitar de uma coleta especial de lixo, a empresa acaba dependendo da coleta pública, que ocorre duas vezes por semana e isso acaba gerando muitas vezes acúmulo de lixo na empresa. Outro aspecto ressaltado é de não haver negócios relacionados à coleta seletiva e reciclagem que poderiam ser adicionados como parceiros na cadeia de descarte da empresa.

Com relação aos processos externos, segundo o gerente-executivo, as demandas impostas aos fornecedores estão muito atreladas ao que os clientes exigem. O que nos remete aos trabalhos seminais de sustentabilidade em cadeias de suprimentos de Beske e Seuring (2014) e Seuring e Muller (2008) ao colocarem que as empresas costumam repassar as exigências dos clientes aos seus fornecedores, podendo várias imposições, mas principalmente na busca de colaboração e desenvolvimento dos fornecedores.

Com relação às práticas externas, há a exigência de determinadas certificações que são feitas aos seus fornecedores, como, por exemplo, as certificações como produtores de orgânicos, a HACCP e *Kosher*. Atualmente a empresa tem buscado também fornecedores com certificação Fair Trade, porém tem dificuldades em encontrar empresas certificadas em produção de frutas tropicais.

Visando a essa questão, o Caso 1 colocou como um desafio interno a busca pela certificação *Food Safety System Certification* (FSSC 22000), que oferece um programa de certificação completa, como a ISO 22000 e o Programa de Pré-Requisitos (PRP), específico do setor, além da HACCP. Para o diretor de

Qualidade, a gestão de risco na empresa só poderá ser feita de maneira mais abrangente mediante a realização dessa certificação.

Com relação aos questionamentos que levam a empresa focal a adotar práticas sustentáveis internas e ao longo de suas cadeias de suprimentos, os entrevistados elencaram algumas motivações, pois o mercado acaba incentivando e impulsionando as empresas para tais mudanças. Essas mudanças fazem com que os colaboradores tenham forças para fazer a empresa crescer e atender às necessidades que o mercado vem impondo, como a implementação da sustentabilidade, que torna sendo uma nova tendência entre os consumidores saudáveis, preocupados com o que estão consumindo.

Os incentivos da empresa focal para a adoção de práticas sustentáveis advêm, sobretudo, dos clientes. De acordo com o encarregado da Qualidade, a inovação no processo produtivo da empresa é uma das principais razões que levam os clientes, principalmente *Business-to-Business*, a trabalharem com a empresa. Sabe-se, portanto, que no mercado internacional há uma valorização cada vez mais crescente por produtos orgânicos, enquanto que existe um grande potencial de aumentar o mercado consumidor doméstico. As certificações foram fundamentais para acessar esses mercados e buscar a competitividade.

A boa comunicação com a alta gestão da empresa é corroborada por seus parceiros internacionais. Além disso, a flexibilidade da empresa, dada pela sua estrutura, permite a exploração de vários produtos que empresas maiores não atendem por serem grandes demais. A partir da aproximação com seus clientes, essa flexibilidade permite à empresa explorar a inovação de produtos a partir da demanda deles.

A empresa passou a testar o desenvolvimento de polpas com concentração maior de vitamina C, por exemplo, utilizando acerola orgânica, que é uma fruta com boa adaptação à região e que possui um bom potencial de mercado internacional. Outra iniciativa está relacionada ao processamento de frutas de modo a utilizar todo o potencial que a fruta pode oferecer.

Quando questionados sobre as principais dificuldades e desafios para um negócio sustentável, os entrevistados pontuam os elevados custos da produção orgânica, a dificuldade de ter ganhos em escala pela capacidade industrial que, consequentemente, afeta a competitividade e a inserção no mercado com preços justos. A certificação, apesar de garantir vantagens aos negócios, incrementa os custos pela necessidade tanto de uma auditoria externa quanto de recursos humanos internos para que a certificação seja alcançada. Além disso, afeta também a atratividade do produto no mercado doméstico.

Em paralelo às dificuldades e desafios que foram identificados na empresa focal, existem outros em relação aos fornecedores ao longo de suas cadeias de suprimentos, como a preocupação com relação à conscientização do capital humano. De modo geral, os colaboradores são pessoas simples, que têm por sua origem o campo, e que não possuem o conhecimento específico sobre práticas sustentáveis, o seu desenvolvimento dentro da organização e de como deve ser a forma correta do manejo do produto até chegar ao consumidor final no mercado competitivo.

4.2 CASO 2

O Caso 2 se refere a uma empresa de pequeno porte fundada em 1992, que trabalha com o beneficiamento da castanha de caju e com o desenvolvimento de alguns produtos derivados da castanha, como, por exemplo: barrinha de cereal de caju, geleia de caju, pasta de amêndoas de castanha de caju, entre outros produtos. A empresa foi fundada com o intuito de desenvolver o vinho do caju no estado do Ceará, porém teve dificuldades de comercialização do produto e acabou se especializando na produção de castanhas e outros derivados da fruta, como a sua polpa.

A empresa atende o mercado doméstico, que abrange o próprio Ceará, e alguns estados como Rondônia, Pernambuco e Goiás. Os seus fornecedores de insumos básicos, como a castanha do caju, são das regiões circunvizinhas ao município de Pacajus.

Destaca-se na história da organização o apoio da Incubadora do Instituto Centro de Ensino Tecnológico (Intece), contando com assessoria tanto na parte tecnológica, nas formulações dos produtos, e também nos aspectos gerenciais, como comercialização e organização estrutural da empresa. Ela também realizou parcerias com a Embrapa Ceará, Senai-CE e Instituto de Tecnologia de Alimentos (Ital) Campinas-SP no intuito do melhoramento de seus produtos.

4.2.1 PRÁTICAS SUSTENTÁVEIS, MOTIVAÇÕES E DIFICULDADES

No desenvolvimento da entrevista com o diretor, percebeu-se que a empresa nasceu visando o beneficiamento e comercialização da castanha de caju, e organizou suas práticas internas ao longo da cadeia de suprimentos baseadas em critérios de qualidade e preço. Contudo, percebe-se que a empresa não entendia a sustentabilidade como um fator de competitividade no mercado, mas que, a partir de sinais do mercado, começou a buscar um maior entendimento sobre a temática.

Quando questionado sobre o que leva a empresa focal a buscar a adoção de práticas sustentáveis ao longo de suas cadeias de suprimentos, o gerente-geral aponta motivações relacionadas às exigências do mercado e que acabam impulsionando mudanças nos seus processos de produção, como, por exemplo, a adoção de boas práticas no campo, exigências que são passadas para os seus funcionários e fornecedores. Essas exigências vão desde o manejo de todos os resíduos produzidos dentro da organização até o processo de descarte dos resíduos, essa é uma questão da sustentabilidade, com isso, ela busca envolver todos os seus parceiros do negócio.

Por ser uma empresa de pequeno porte, cujos recursos financeiros são limitados, e por não dispor de pessoas especializadas em sustentabilidade, a adoção das boas práticas no campo é a sua orientação maior para a sustentabilidade aplicada aos seus parceiros.

Já no que diz respeito às principais dificuldades para implementação de práticas sustentáveis na sua organização e ao longo da cadeia, o gerente-geral apresenta que há uma dificuldade para contratação de mão de obra qualificada para executar as atividades e falta um preço mais competitivo para o mercado, preços justos que acabem valorizando o trabalho dos pequenos produtores. Percebe-se que falta uma atratividade para as Pequenas e Médias Empresas concorrerem no mercado doméstico com relação à concorrência com grandes empresas na zona industrial da cidade, além de faltarem incentivos governamentais e capital próprio da organização.

Em paralelo às dificuldades e desafios que os fornecedores encontram, é perceptível a preocupação com relação às várias demandas de produtos que são solicitados pelos clientes e suas exigências quanto à qualidade dos produtos oferecidos.

4.3 ANÁLISE DOS RESULTADOS

A análise das duas organizações é feita sobre as semelhanças e diferenças existentes. Percebe-se, nos casos estudados, realidades bastante diferentes no que tange à inserção da sustentabilidade nas empresas, bem como nas suas cadeias de suprimentos. Ainda que a literatura traga um arcabouço de práticas usadas por PMEs no mundo (BATTISTI; PERRY, 2011; JOHNSON; SCHALTEGGER, 2016), o que se evidenciou nesses casos estudados é que as práticas sustentáveis, ainda que seja um fator estratégico (como se relata no Caso 1), ainda são poucas quando comparadas a outros casos.

De modo específico aos resultados do Caso 1, destaca-se que a empresa nasceu oriunda de programas de incubação em parcerias com instituições de fomento à pesquisa reconhecidas, como a Embrapa. Na sua essência, tem-se a inovação e a busca por diferenciação no mercado, o que levou à execução de uma parceria com uma empresa de grande porte para ganhar competitividade no mercado, na busca de solucionar uma dificuldade na sua capacidade industrial. Pode-se evidenciar que as práticas de sustentabilidade do Caso 1 estão mais voltadas para a exigência de certificação de produtos orgânicos para com seus fornecedores, pois são frutos de pressões do mercado consumidor externo.

Já no Caso 2, a realidade observada foi distinta, sendo as suas práticas mais voltadas para o mercado convencional da castanha de caju, e sem a existência de certificações nos produtos da organização. Na percepção do gestor, a empresa tem suas práticas de sustentabilidade advindas das boas práticas do campo e quando se fala do licenciamento ambiental, pois se tem que cumprir vários critérios que envolve a sustentabilidade para obtenção deste, visando uma melhor qualidade do produto oferecido aos seus consumidores. A empresa atua no mercado nacional e os seus clientes acabam não pressionando a organização para a adoção de tais práticas sustentáveis. Contudo, a organização tem um olhar para o que envolve a inovação dos seus produtos visando atender o mercado externo.

Muitos autores discutem que o que leva as organizações a implementarem essas práticas de sustentabilidade no ambiente interno da empresa, bem como na sua cadeia de suprimentos, são os incentivos que partem dos seus stakeholders, buscando o desenvolvimento dessas ações de forma gradual dentro da organização, e pressões externas impostas pelos consumidores e governo (DONATO *et al.*, 2016).

Vale ressaltar que, diante dos casos estudados, observou-se que tanto no Caso 1 quanto no Caso 2, ambas na composição trazem divergências com relação à implementação ou realização de práticas sustentáveis nas suas cadeias.

Portanto, o Caso 1 e o Caso 2 evidenciam a preocupação com os aspectos que contemplam a questão ambiental, tratando-a a partir da promoção de práticas sustentáveis que incorporam a busca por novas tecnologias que ajudem a minimizar o impacto ambiental, social e econômico. As empresas, em suas etapas de produção, buscam uma melhor eficácia na utilização de seus recursos, já que se têm certas dificuldades em selecionar fornecedores certificados (Caso 1) no que diz respeito aos fornecedores de produtos que demandam recursos orgânicos, ou (Caso 2) quando buscam fornecedores com qualidade na castanha oferecida.

A partir das falas, percebe-se quais são as principais motivações que as organizações relataram em suas entrevistas com relação à adoção de práticas sustentáveis, esse entendimento está correlacionado aos achados teóricos da pesquisa, e podemos evidenciar no Quadro 1.

Quadro 1 | Motivações para adoção de práticas sustentáveis nas PMEs.

	Teoria	*Caso 1*	*Caso 2*
Motivações	Redução de custos; Cumprimento da regulação; Reputação e melhoria da imagem institucional perante os clientes e fornecedores; Melhoria dos relacionamentos com os *stakeholders*;	Obtenção de lucros; Produtos de maior valor agregado sustentáveis; Sustentabilidade da empresa e seu equilíbrio; Preço da matéria-prima; Sensação de realização e satisfação pessoal; Destinação devida dos resíduos;	Atender ao anseio do consumidor; Produto diferenciado no mercado com qualidade e diferencial competitivo; Boa amizade; Produto de qualidade; Qualificado para o mercado; Produtos naturais.

	Teoria	Caso 1	Caso 2
Motivações	Pressões de clientes; Disseminação de informações; Investimento e tomada de decisão a favor da sustentabilidade. (Battisti; Perry, 2011; Cassells; Lewis, 2011; De Barcellos *et al.*, 2011; Haln; Scheermen, 2005; Johnson; Schaltegger, 2016; Neto *et al.*, 2017; Oxborrow; Brindley, 2013; Revell *et al.*, 2009)	Busca pela excelência em ter um processo mais limpo; Abertura de mercado orgânico; Aceitação dos produtos por parte dos clientes; Confiança nos fornecedores; Clientes parceiros; Preço justo que cubram os custos; Melhor remuneração por parte de outra organização	

Fonte: Elaborado pelos autores (2022).

Quando analisadas as principais dificuldades para a adoção de práticas sustentáveis nas empresas que compõem o Caso 1 e o Caso 2, podemos evidenciar essas dificuldades a partir do Quadro 2, no qual são relatados os principais pontos levantados nas entrevistas da empresa focal.

Quadro 2 | Dificuldades para inserir práticas sustentáveis na empresa focal.

	Teoria	Caso 1	Caso 2
Dificuldades	Recursos financeiros limitados; Falta de mão de obra qualificada; Alto custo inicial para implementação das ferramentas (certificações); Falta de informações/ conhecimento; Falta de financiamento/ incentivos governamentais; Complexidade das ferramentas de gestão; Regulamentação sustentável. (Casalino *et al.* (2014); Cassells; Lewis (2011); Conway (2015); Conway *et al.* (2015); Esselaar *et al.* (2007); Fialho; Mota; Neutzling (2019);	Produzir produto natural e orgânico; Mercado competitivo; Produto ideal com qualidade; Preço ideal praticado no mercado; Menores custos; Seleção de fornecedores; Matéria-prima; Certificação de orgânicos; Falta de fiscalização; Mão de obra qualificada; Qualidade do produto oferecido pelos fornecedores; Conscientização dos produtores quando o assunto é sustentabilidade; Custos altos para produzir orgânicos; Exploração dos preços de produtos orgânicos;	Recursos financeiros limitados; Descrença do benefício percebido; Falta de mão de obra qualificada; Falta de informações/ conhecimento; Falta de consciência das questões ambientais; Capacidade de Inovação; Falta de financiamento/ incentivos governamentais; Complexidade das ferramentas de gestão; Regulamentação sustentável; Castanha na mão de corretores; Falta de sensibilidade para a importância da sustentabilidade dos produtores;

	Teoria	Caso 1	Caso 2
Dificuldades	Ghazilla *et al.* (2015); Hasan (2016); Hjorth e Brem (2016); Ismail *et al.* (2011); Jaramillo *et al.* (2019); Johnson; Schaltegger (2016); Lee (2009); Lewis *et al.* (2015); Oxborrow; Brindley (2013); Sulong *et al.* (2015); Tsalis *et al.* (2013).)	Manutenção do campo sem produtos agrotóxicos; Mercado muito restritivo; Faltam grandes indústrias com padrão internacional nas regiões Norte e Nordeste; Competitividade; Desenvolvimento de testes nos produtos; Custos de auditoria e conhecimentos; Manutenção de equipamentos.	Falta de conhecimento sobre sustentabilidade; Preço justo da castanha; Óleo *diesel*, gasolina e mão de obra subindo os preços; Logística.

Fonte: Elaborado pelos autores (2022).

Segundo a literatura, podemos encontrar e corroborar os achados da pesquisa para implementação de práticas sustentáveis nas PMEs dificuldades como: a falta de recursos financeiros, descrença dos benefícios, falta de mão de obra qualificada, alto custo inicial para implementação de ferramentas, falta de informações gerais, falta de tempo, pouca ou nenhuma consciência interna e externa das questões sobre sustentabilidade, regulamentação, falta de financiamento e incentivos governamentais, pouca capacidade de inovação e complexidade das ferramentas de gestão (JARAMILLO *et al.*, 2019).

Vale salientar que a descrença dos benefícios é uma dificuldade rotineira que impede os gerentes/proprietários de direcionar valores e esforços às questões sustentáveis (JOHNSON; SCHALTEGGER, 2016), por não acreditarem no retorno financeiro e por serem céticos quanto aos benefícios sustentáveis (CONWAY, 2015).

Como descrito na literatura, as cadeias de suprimentos de PMEs exercem práticas e métodos sustentáveis, apesar de serem em menor extensão ante as grandes organizações (SPASESKI, 2014). Nessa perspectiva, podemos relatar as práticas sociais que ambas as empresas apresentam nas suas entrevistas, enfatizando os impactos que suas organizações trazem para as comunidades nas quais estão inseridas, proporcionando para as pessoas nativas uma geração de renda e valorização do capital humano ali encontrado, gerando melhor qualidade de vida, incentivo à cultura local, estabelecendo, assim, relações duradouras, baseadas na confiança, porém essas práticas de sustentabilidade na perspectiva das PMEs são limitadas (ASHBU; HUDSON SMITH, 2018; BATTISTI; PERRY, 2011; COSTA *et al.*, 2010; GHADGE *et al.*, 2017; JOHNSON; SCHALTERGGER, 2015; KOBERG; LONGONI, 2019; KOT, 2018).

Para um melhor entendimento sobre a falta de adoção de práticas sustentáveis nas PMEs investigadas, foi realizada uma rodada de entrevistas com especialistas que dão suporte a essas PMEs. A análise feita pelos especialistas com base no contexto apresentado é que, na cadeia de subprodutos de caju, principalmente castanha de caju, por se tratar de uma *commodity*, a questão da sustentabilidade ainda não é vista como determinante para ser competitiva no mercado. No entanto, na medida em que os subprodutos (sucos clarificados, cajuína, carne de caju) se destacam no mercado, as práticas de sustentabilidade podem se tornar um fator competitivo. Dessa forma, a adoção das práticas é determinada pelos mercados de atuação desses negócios.

Outro ponto é que existem incentivos por parte do governo do estado do Ceará, porém não atendem toda a categoria das PMEs, e especificamente a projetos de sustentabilidade, o que dificulta um investimento mais direcionado.

As implicações da gestão da sustentabilidade ao longo da cadeia de suprimentos de Pequenas e Médias Empresas, quando estas são ainda empresas focais, recaem na fundamental importância de parcerias com organizações de pesquisa e de assistência de negócios, e da confiança estabelecida com os fornecedores (COSTA *et al.*, 2010; KOBERG; LONGONI, 2019). No caso da pesquisa, evidencia-se a atuação junto à Embrapa, Senai, Sebrae e núcleos de pesquisa e consultoria ligados às universidades do estado. Corroborando os achados da pesquisa, a literatura aborda a existência do reconhecimento de que nas cadeias de suprimentos de PMEs, os relacionamentos são altamente pessoais (ASHBY; HUDSON SMITH, 2018).

5 CONCLUSÕES E RECOMENDAÇÕES

As empresas estudadas nesta pesquisa se enquadram nos requisitos de pequenas e médias empresas de acordo com o Sebrae. Elas demonstram inclinação para o desenvolvimento de práticas sustentáveis devido às demandas das legislações ou quando o mercado exige, confirmando a investigação feita pelo Sebrae com empresários que se predispõem a tais práticas em suas organizações, visando ao debate na Conferência das Nações Unidas sobre Desenvolvimento Sustentável, no ano de 2012 (SEBRAE, 2012). Embora para as organizações desenvolverem e colocarem em prática a sustentabilidade ela seja um critério mínimo para funcionamento, as indústrias tendem a aumentar suas práticas com medidas simples que envolvam a sustentabilidade.

Diante dos resultados, percebe-se que as empresas têm um nível diferente de entendimento sobre o que é a sustentabilidade, com conhecimentos, percepções e necessidades de mercados diferentes ao longo da existência de cada organização.

Pode-se perceber que os dois casos analisados apresentam realidades semelhantes de contexto, devido ao setor de atuação e estrutura da cadeia de suprimentos, mas são diferentes na orientação e realização de atividades voltadas às práticas de sustentabilidade. No que se refere a essas práticas, no Caso 1 as evidências mostram que a empresa possui suas práticas voltadas ao setor de exportação que a empresa realiza, com exigências de certificação de produtos orgânicos, bem como outras certificações, o que leva aos seus fornecedores terem que cumprir vários requisitos que contemplam a sustentabilidade na sua cadeia de suprimentos. Já no Caso 2, as práticas de sustentabilidade estão voltadas ao desenvolvimento de atividades que contemplam a qualidade do produto oferecido aos seus consumidores.

Os resultados da pesquisa apontam para a necessidade de estudos mais completos no sentido de integrar as temáticas de sustentabilidade e cadeia de suprimentos. Para que seja alcançada uma GSCS, são necessárias mudanças nos paradigmas que contemplam a sustentabilidade nas organizações, assim como maneiras de fazer com que ela deixe de ser vista como um custo para as organizações e passe a representar uma potencial fonte de vantagem competitiva no mercado.

A pesquisa apresenta como principal contribuição a evidência das práticas de sustentabilidade e a descrição dos motivadores de PMEs a terem atitudes que contemplam a adoção de práticas sustentáveis. Em contrapartida, observam-se que os desafios que as empresas encontram para a adoção de tais práticas são afetados pela falta de recursos das organizações, que repercute em poucos investimentos em tecnologias, mão de obra e conhecimento para implementação da sustentabilidade, que se amplia com a falta de incentivos por parte do poder público para atender a tais lacunas.

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Impact of heat waves on cardiovascular and respiratory morbidity and mortality in municipalities of Northeast Brazil

Impacto das ondas de calor na mobilidade e mortalidade cardiovascular e respiratória em municípios do Nordeste do Brasil

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ARTICLE – VARIA

ABSTRACT

In the last few years, many studies have researched the impacts of heat waves on population health. However, very few focus on the Brazilian context. This study aims to analyse the impact of heat waves on the cardio-respiratory health of the northeastern population, analysing how heat waves from October to March increase the risks of morbidity and mortality in the population of five municipalities. It is observed that January, February and October present more morbidity and mortality cases in the population and that the municipality of Belém del San Francisco presents the highest odds of increased health risk from heat waves. Additionally, a positive signal was found between heat waves and cardiovascular hospitalisations for many heat wave definitions. A time stratified cross-case design was used to study the association between heat waves, deaths, and hospitalisations.

Keywords: Heat waves. Temperature. Variability. Mortality. Morbidity. Health impacts.

RESUMO

Nos últimos anos, um grande número de estudos tem sido gerado sobre os impactos causados pelas ondas de calor na saúde da população, porém, muitos deles fora do país. Esse estudo tem como objetivo analisar o impacto das ondas de calor na saúde cardiovascular e respiratória da população nordestina, analisando como as ondas de calor de outubro a março aumentam os riscos de morbimortalidade da população de cinco municípios. Observa-se que os meses de janeiro, fevereiro e outubro são os que mais apresentam casos de morbimortalidade da população e, que o município de Belém do São Francisco, apresenta a maior probabilidade de risco. Além disso, um sinal positivo consistente foi encontrado entre as ondas de calor e a hospitalização cardiovascular. Metodologicamente, foi usado um desenho cruzado estratificado de casos para estudar a associação entre onda de calor e óbitos e hospitalizações.

Palavras-chave: Ondas de calor. Temperatura. Variabilidade. Mortalidade. Morbidade. Impactos na saúde.

1 INTRODUCTION

Heat waves adversely affect human health and drive increased deaths (ALCALÁ, 2019; ANDERSON, 2009; ARMSTRONG, 2014; GUO, 2017; NATIONAL, GUERRERO, 2018; PÉRES, 2020). This was evident after the intense heat wave that affected 16 European countries in 2003 and caused the death of 70,000 people. According to a study by Alcalá (2019), the magnitude, duration and intensity of heat waves increased globally between 2003 and 2018. The authors show that in 2018 heat waves recorded in Asia, North America, Europe, and Oceania caused 1,500 deaths globally.

This article aims to analyse the impact of heat waves on the cardiovascular and respiratory health of the northeastern population of Brazil. We analysed how heat waves from October to March increased the risks of morbidity and mortality in the population of five municipalities. Many studies have shown that the variability of air temperature (AT) and heat waves affect morbidity and mortality rates and particularly those that are most vulnerable (ANDERSON, 2009; ARMSTRONG, 2014; BERNAL *et al.*, 2014; GREEN *et al.*, 2015; GUO, 2017; LI *et al.*, 2015). In Brazil, some studies have shown an association between heat waves, air temperature and mortality, and socioeconomic characteristics of the population can drive increased vulnerability (GEIRINHAS *et al.*, 2020). According to these studies, in different parts of the country, temperature and humidity influence general mortality indicators and specific causes. Other studies indicate that heat waves generate a series of impacts on human health in various regions studied (BAUTISTA *et al.*, 2011; CARVER; SHEIER, 2014; ERCIDES, 2020; GEIRINHAS *et al.*, 2019; GUO *et al.*, 2015; IKEFUTI, 2018; LAERTE *et al.*, 2016; SILVEIRA *et al.*, 2019).

Silveira *et al.* (2019) investigated the total effect of temperature on cardiovascular mortality in 27 Brazilian cities, for example, and demonstrated the existence of risks associated with temperature. They show that cardiovascular mortality is associated with low and high temperatures in most cities in Brazil. Zhao *et al.* (2019) quantified the relationship between heat and hospitalisation by the time of year and the climatic conditions of 1,642 cities during the hot seasons of 2000-2015, showed that the number of hospitalisations was associated with average daily temperature, increasing in the season late warm compared to the early warm season. The author highlights that this effect is registered similarly between women and men. However, people older than 75 years are more affected.

Laerte *et al.* (2016) evaluated the effect of climatic seasonality on respiratory symptoms in the tropical city of Goiânia (GO) and observed that the number of individuals with respiratory symptoms increased significantly with the reduction of relative humidity, which the analysis of regional meteorological data could predict. On the other hand, Ikefuti (2018) evaluated the associations between stroke and air temperature from 2002 to 2011 in São Paulo and showed that air temperature increased mortality from stroke for both men and women.

Analysing the impact of heat waves on the cardiorespiratory health of the population, the World Health Organization (WHO) states that the climate and its abrupt variations have an essential role in the mortality and morbidity of the population (ALCALÁ, 2019; SURVEILLANCE, 2004; WHO, 2014), showing that the climatic factor constitutes a risk factor for the health of vulnerable populations. It is estimated that abrupt temperature variability and the emergence of heat waves, as a result of climate change, will drive increases in mortality and morbidity of the population in the coming years (ALCALÁ, 2019; SURVEILLANCE, 2004). Therefore, it will be necessary to carry out specific studies to generate adaptation measures and early local warnings to generate resilience for affected populations (CONLON *et al.* 2011; KINGDOM, 2011). Therefore, understanding the most relevant thresholds to reveal the impact of heat waves on health is essential, making it possible to activate early warning systems and protect the population effectively.

Studies carried out in Brazil studying the health impacts of heat have predominately focused on the country's main cities, with little attention to smaller cities where social and economic conditions may differ. Therefore, it is crucial to carry out studies in these areas to generate scientific data that contribute to the generation of early warnings in these regions. By generating evidence on the risk factors in these cities, local authorities can take the corresponding actions to improve the health services and protect population health (LUCCHESE, 2004; MACHADO *et al.* 2017). The research results can also increase the knowledge of the impacts of climatic phenomena related to temperature on morbidity and mortality in semi-arid regions of Brazil, enabling the generation of public policies that help health service providers and the local population to better face these human health threats.

2 STUDY AREA

The San Francisco basin in Brazil is considered one of the most important in the country because, firstly, it is one of the largest in the region and also because it has relevant economic, cultural and social importance, particularly for the population settled in the Northeast and Southeast region of the country. The river has a drainage area of 634,781 km^2, representing 8% of the national territory, covering 503 municipalities and forming part of seven States of the Federation: Bahia, Minas Gerais, Pernambuco, Alagoas, Sergipe, Goiás and the Federal District. The basin is divided into four physiographic sub-regions (Upper mid, sub mid, mid and lower San Francisco) and has been affected by prolonged droughts and extreme aridity (HERMUCHE, 2002).

Each of the four physiographic regions of the basin is characterised by different types of climate, soil and vegetation cover. This study was carried out in municipalities that correspond to the Submédio de San Francisco (SubM-SF), which has a semi-arid and arid climate and registers an average annual rainfall that ranges between 800 and 350 mm and an average annual temperature of 27º C., 2,800 hours of sunshine, and 1,550 mm of average annual evapotranspiration (MOURA *et al.*, 2006).

The SubM-SF region is characterised by water scarcity, climatic extremes, unpredictable rainfall and high evapotranspiration (MARENGO *et al.*, 2018; SHUKLA, 1981). Maximum and minimum temperatures of the studied area occur during November and July, respectively, registering a maximum temperature of 28.05o C and a minimum of 22.89º C.

This research analysed the impact of heat waves on the health of the population living in the municipalities of Belém do São Francisco, which has 20,253 inhabitants according to the 2010 census, Floresta with 29,285, Itacuruba with 4,369, and Petrolândia with 32,492, Jeremoabo with 37,680 and Paulo Afonso with 108,396 inhabitants. These territories correspond to the states of Bahia and Pernambuco (Figure 1).

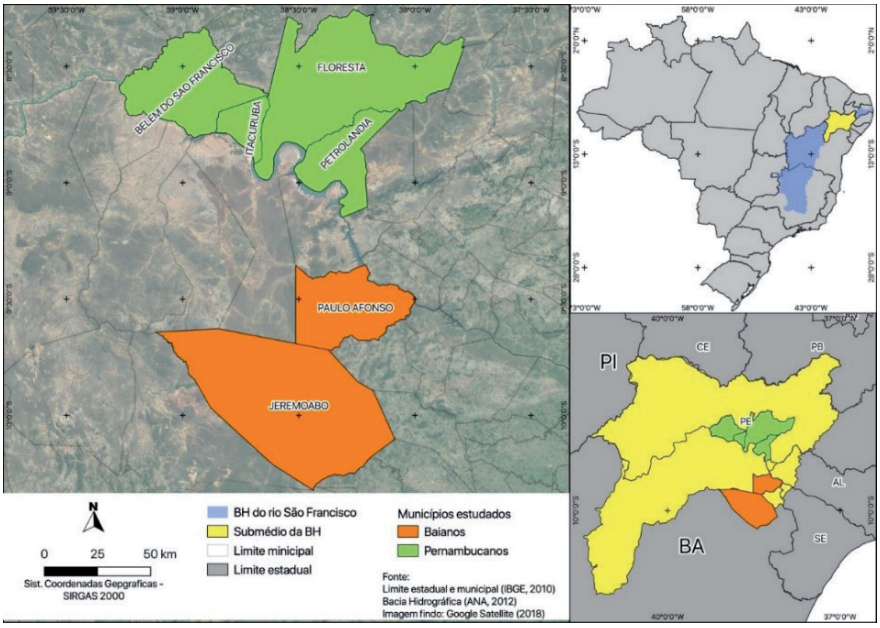

Figure 1 | Map of the study area in the Sub-Medium region of San Francisco.

Source: Authors elaboration.

3 METHODS

Since 2018, the Brazilian Climate Change Research Network (REDE CLIMA for its acronym in Portuguese) and the Socio-environmental Dynamics Observatory (INCT – ODISSEIA) have been conducting field research together with indigenous peoples and communities of the Sub-Medium region of the San Francisco Basin to analyse the impacts that climate change has been causing on the local population.

In this case, the objective of this research was to evaluate the effect of climatic seasonality on the occurrence of hospitalisations and deaths of patients with cardiovascular and respiratory diseases treated at a local Basic Health Unit (UBS) (See Table 1). The study was developed from the analysis of primary data from the period (January 2008 to September 2019), which were provided by the General Coordination of Information and Epidemiological Analysis (CGIAE), the area responsible for the Mortality Information System (SIM) of the Ministry of Health of Brazil.

In this study, a heat wave event was defined as when the maximum temperature exceeds a percentile threshold (99, 97.5 or 95) of the temperature distribution for each region within a specific month or season from January 2008 to March 2019. The heat wave defined by the days of extreme heat within the spring and summer seasons (October-March) were considered for this analysis. Monthly heat wave definitions were also created and defined as the temperature exceeding the percentile threshold per month, considering days of extreme heat each month. All definitions were considered as one- or two-day heat wave events when the temperature reaches the percentile threshold (99, 97.5, or 95) for two consecutive days. These various definitions were taken into account to determine the ideal measure for heat waves and determine in which months or seasons the strongest associations are observed. September was omitted because this month was considered a transition month with the coldest season of the year, winter.

Regarding the statistical analysis, a time stratified case-crossover design was used to study the association between each definition of a heat wave and deaths and hospitalisations of cardiovascular and respiratory diseases (BASU, 2008; BASU; OSTRO, 2008; TONG, 2012). The methodology is similar to the design and analysis of a case-control study. However, here the controls are identified for the same individual as the cases in the study population; therefore, only variables that vary over time are

considered covariates. Control days were selected based on the same day of the week of admission to the hospital within the same month and year in which the case occurred. Percentiles (97.5 and 99) were chosen for the definitions of heat wave events for this analysis to identify days of extreme heat.

A conditional logistic regression model was used to study the association between heat waves, deaths, and hospitalisations for each definition of a heat wave and hospitalisation diagnosis. Precipitation was used as a covariate to adjust for humidity, and each heat wave definition and hospitalisation diagnosis for the entire region and each municipality were analysed separately.

We also analysed the climatic variability of the municipalities addressed between the period (1989 - 2019). This was done with geospatial satellite data corresponding to NASA's *The Power Project*. Primary solar and meteorological data sources made available by NASA are natively produced on a 1° x 1° global latitude/longitude grid and resigned to a 0.5° x 0.5° latitude/longitude grid by interpolation or bilinear replication (THE POWER PROJECT, 2020). Once the data had been analysed, they were compared to the results of other regional studies to confirm the deductions obtained (GAIVIZZO *et al.*, 2019; MARENGO, 2009; RODRIGUES FILHO, 2016; SILVA *et al.*, 2011; TEIXEIRA, 2016).

The climatic data acquired were analysed by associating the number of deaths and hospitalisations of the local population, and the results obtained in the regression could inform future risks related to heat waves.

It should be noted that this study complies with the standards and requirements of the Research Ethics Committee of the Faculty of Human and Social Sciences of the University of Brasilia (UnB), which is duly registered in process No. 01037218.5.0000.5540 and opinion of approval No. 3,440,596.

4 RESULTS

4.1 CLIMATE VARIABILITY IN THE STUDIED REGION

As stated, several studies show how climatic factors can harm vulnerable populations' health, which demonstrates the importance of studying how temperature variability and heat waves can play a role in increasing mortality and morbidity. It is believed that there will be an increase and decrease in temperatures in the coming years due to climate change in some seasons of the year, driving increases in mortality (CONLON *et al.* 2011; KINGDOM, 2011).

Therefore, it becomes relevant to carry out evaluations of these temperature extremes to generate projections of health impacts and to generate adaptation measures to promote resiliency for affected populations.

A slight increase in temperatures is observed from 1989 - 2019 in the region studied, reaching an annual average of 0.5º C (See Figure 2). The year with the lowest temperature was 1989, reaching 25.42º C; the hottest was 1998, when 27.08 º C was recorded.

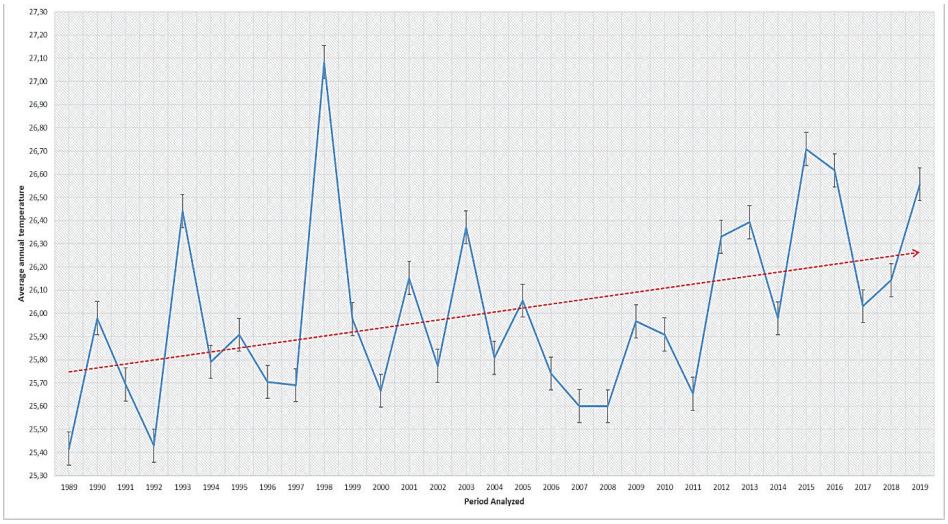

Figure 2 | Variation in the average annual temperature recorded in the study area, 1989 - 2019.

Source: Authors' elaboration, with data from NASA Prediction of Worldwide Energy Resources (Power). Higher Resolution Daily Time Series by Location 1/2 x 1/2 degree.
Climatology Resources for SSE - Renewable Energy. Bottom-left Latitude: -10.2640 Longitude: -39.0400. Upper-right Latitude: -8.4705 Longitude: -38.0270.

The maximum and minimum temperatures recorded corresponded to November and July, and we can more clearly observe an increase in the average temperature in these months (See Figure 3). For example, in the first years of the analysed period, it is observed that the average temperature for November was 27.7º C, a value that went to 28.6º C in recent years, showing an increase of approximately (1º C).

Concerning the variability of the lowest temperature recorded in July, in the same way, we observed a slight increase throughout the analysed period. In the first years, the average reached 22.5º C and the later years registered 23.4º C. Temperature variation can influence the increase or decrease in morbidity cases and mortality in the local population; the figures below show the historical temperature exposure for the region.

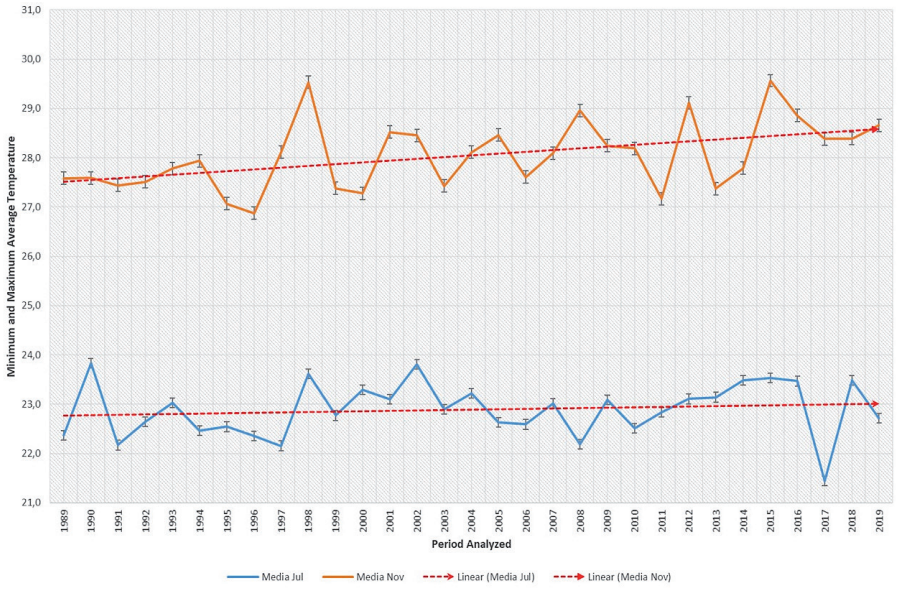

Figure 3 | Variation in the average annual temperature recorded in the study area, 1989 - 2019.

Source: Authors' elaboration, with data from NASA Prediction of Worldwide Energy Resources (Power). Higher Resolution Daily Time Series by Location 1/2 x 1/2 degree.
Climatology Resources for SSE - Renewable Energy. Bottom-left Latitude: -10.2640 Longitude: -39.0400. Upper-right Latitude: -8.4705 Longitude: -38.0270.

4.2 HEAT WAVES, MORBIDITY AND MORTALITY OF THE LOCAL POPULATION

Our study population included 22,896 hospitalisations and 1,265 deaths in the municipalities of Belém do São Francisco, Floresta, Itacuruba, Petrolândia, Jeremoabo and Paulo Afonso territories corresponding to the states of Bahia and Pernambuco from January 2008 to September 2019 (See Table 1).

Table 1 | Description of total hospitalisations and deaths both diseases. 2008-2019

Municipality	*Hospitalizations for both diseases*	*Deaths (%)*
Belém de São Francisco	1229 (43.0)	19 (47.4)
Floresta	3491 (43.9)	128 (49.2)
Itacuruba	175 (46.9)	twenty
Jeremoabo	1553 (39.0)	104 (39.4)
Paulo Afonso	12,120 (43.6)	917 (47.3)
Petrolândia	4,328 (42.8)	95 (45.3)
TOTAL	22,896	1,265

Source: Prepared by the authors with data from the General Coordination of Information and Epidemiological Analysis (CGIAE).

Table 2 | Description of definitions of heat waves by summer period

For summer period				
Season	*Definition of heat wave*	*Threshold percentile and median temperature (°C)*	*Duration (days)*	*Number of days by municipalities*
summer	HWD1	99 (31.7)	1	123
summer	HWD2	99 (31.9)	2	51
summer	HWD3	97.5 (31.3)	1	317
summer	HWD4	97.5 (31.5)	2	155
summer	HWD5	95 (30.9)	1	617
summer	HWD6	95 (31.1)	2	347

Source: Elaboration of the authors.

The temperature thresholds for the definitions of heat waves and the number of heat waves that occurred are described in Table 2. The lowest threshold for temperature in all municipalities had an average of 29.9ºC for the two-day heat waves defined at per cent 99 in January. The highest of all heat wave definitions was 32.5ºC for 2-day heat waves, defined at 97.5 per cent in November (See Table 3).

Table 3 | Description of definitions of heat waves by month

Per month				
Season	*Definition of heat wave*	*Threshold percentile and median temperature (°C)*	*Duration (days)*	*Number of days by municipalities*
October	HWD1o	99 (31.2)	1	21
October	HWD2o	99 (32.1)	2	5

Per month				
Season	Definition of heat wave	Threshold percentile and median temperature (°C)	Duration (days)	Number of days by municipalities
October	HWD3o	97.5 (30.9)	1	54
October	HWD4o	97.5 (31.0)	2	21
October	HWD5o	95 (30.5)	1	106
October	HWD6o	95 (30.7)	2	57
November	HWD1n	99 (32.4)	1	22
November	HWD2n	99 (32.5)	2	8
November	HWD3n	97.5 (31.7)	1	50
November	HWD4n	97.5 (32.5)	2	8
November	HWD5n	95 (31.3)	1	99
November	HWD6n	95 (31.5)	2	46
December	HWD1d	99 (31.6)	1	16
December	HWD2d	99 (31.0)	2	4
December	HWD3d	97.5 (31.6)	1	53
December	HWD4d	97.5 (31.7)	2	23
December	HWD5d	95 (31.4)	1	107
December	HWD6d	95 (31.6)	2	65
January	HWD1e	99 (30.9)	1	20
January	HWD2e	99 (29.9)	2	2
January	HWD3e	97.5 (30.5)	1	56
January	HWD4e	97.5 (30.7)	2	21
January	HWD5e	95 (30.2)	1	117
January	HWD6e	95 (30.7)	2	21
February	HWD1f	99 (30.6)	1	20
February	HWD2f	99 (30.6)	2	2
February	HWD3f	97.5 (30.5)	1	49
February	HWD4f	97.5 (30.6)	2	24
February	HWD5f	95 (30.2)	1	96
February	HWD6f	95 (30.4)	2	53
March	HWD1m	99 (31.24)	1	21
March	HWD2m	99 (31.3)	2	9
March	HWD3m	97.5 (30.7)	1	57
March	HWD4m	97.5 (30.8)	2	27
March	HWD5m	95 (30.4)	1	109
March	HWD6m	95 (30.5)	2	63

Source: Elaboration of the authors.

When exploring the association between heat wave days, hospitalisations and deaths, there was some variability, observing a positive signal between heat waves and cardiovascular hospitalisation, particularly in two-day heat waves (See Figure 4). The results mainly show us that heat waves cause a greater effect on cardiovascular morbidity, mainly the day after the heat wave and in heat waves lasting two days. In the case of respiratory morbidity, the data show a slight impact. However, the results were imprecise.

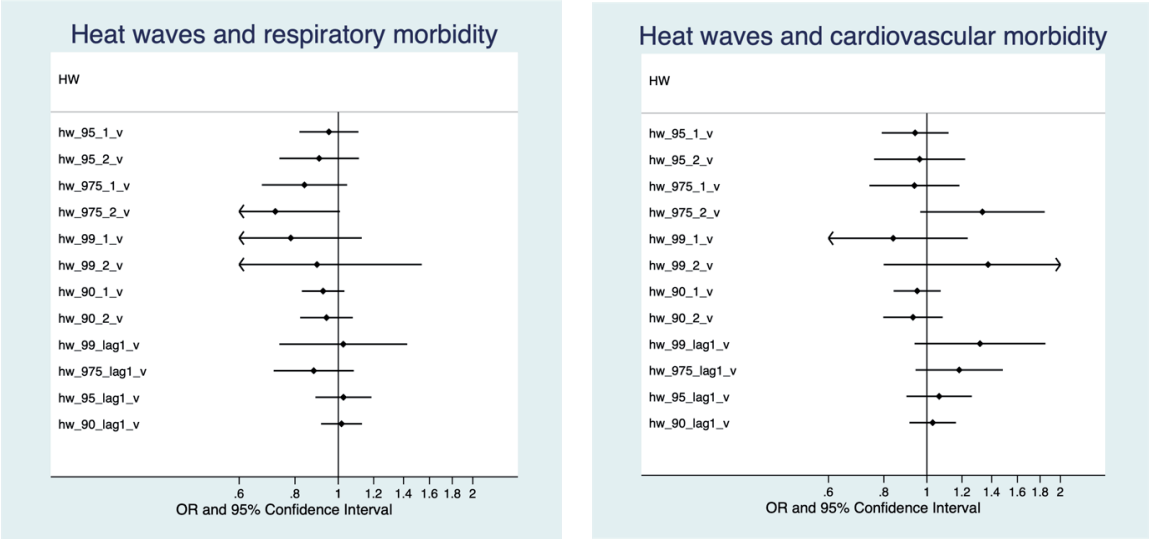

Figure 4 | Impact of heat waves on cardiovascular and respiratory morbidity.
Source: Elaboration of the authors. Results of time-stratified crossover case analysis.

Because our analysis's sample of deaths was small, we focused on hospitalisations as the primary outcomes. We generally find more impact from heat waves defined by month than those defined by the whole period. For example, in January, we observed a higher risk of hospitalisation in the population when heat waves are recorded (Figure 5). As can be seen, the effects of heat waves are positive at the beginning of January, February and October, during which there would be a greater probability of cardiovascular and respiratory hospitalisations.

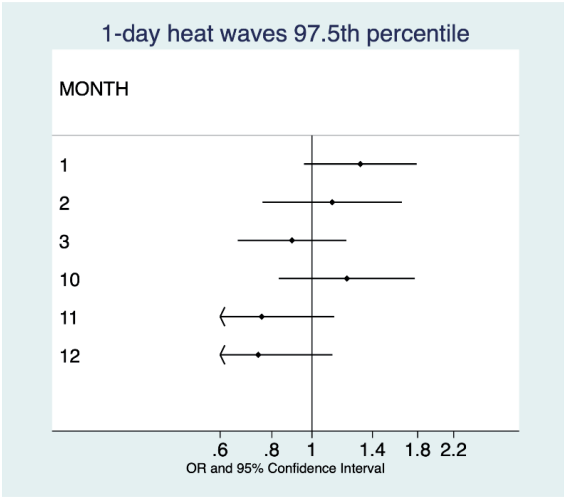

Figure 5 | Heat wave impact defined by month for 1-day heat waves at the 97.5 percentile
Source: Elaboration of the authors. Stratified crossover case analysis.

Considering the results by municipality, we observe that the population most exposed and prone to respiratory and cardiovascular problems from heat waves in these periods are in the municipality of Belém do Sao Francisco, with an odds ratio of 1.85 (95% CI: 0.99, 3.43).

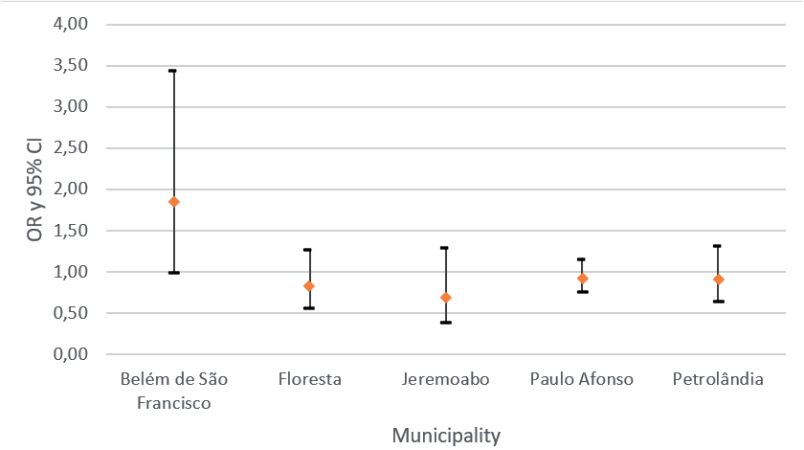

Figure 6 | Effect of heat waves by department
Source: Authors' elaboration, results of time-stratified crossover case analysis.

5 DISCUSSION AND CONCLUSION

The analysis of health data obtained at the municipal level shows us that heat waves from October to March influence the number of morbidity cases in the northeastern population, particularly in Belém do São Francisco. Therefore, this municipality should prepare to respond to the increase in cases as temperature increases are expected.

The analysis of regional climate variability shows us an increase of approximately 1º C from 1989 to 2019. This could have increased the number of cases in recent years, mainly in the months that show the highest number of cases, since, as can be seen, there is an abrupt temperature variability (See Figure 3).

The increase in cases in certain months could be driven by abrupt temperature variation and heat waves (ANDERSON, 2009; ARMSTRONG, 2014; BAUTISTA *et al.*, 2011; CARVER; SHEIER, 2014; GEIRINHAS *et al.*, 2019; GUO, 2017; GUO *et al.*, 2015; IKEFUTI, 2018; SILVEIRA *et al.*, 2019). For example, Silveira *et al.* (2019) observed the effect of temperature and heat waves on cardiovascular mortality in 27 Brazilian cities.

Socioeconomic or physiological factors can increase vulnerability to extreme heat, making it essential to promote policies that aim to reduce existing risks with health services and social-economic disparities (ERCIDES, 2020; SARRÓ, 2009). Housing, work and population dynamics can also play a role in the impacts observed; illegal settlements where improvisation of access to basic services is common in this region can also increase their health risk increasing vulnerability to climatic stressors (YANG *et al.*, 2019).

This point could not be evaluated in the present investigation due to the objective and the data analysed. However, we consider that it would be advantageous to analyse in future work since they would better help to see the effects of heat waves on population health. One of the limitations encountered in order to analyse the problem exposed in this work, comparing it to other similar realities, was the limited existence of studies carried out in Brazil and in the region, for which it is considered necessary to generate more epidemiological evidence to corroborate what was stated and reduce the vulnerability of the affected population. Additionally, obtaining data on mortality and morbidity by the municipality was another limitation, restricting the study to only be carried out in six of the fifteen municipalities for which information was requested.

It is essential to consider improvements in the recording and dissemination of data that can be used to carry out this type of analysis and find a solution to these uncertainties, as well as the establishment of regional and municipal early warnings, with emphasis on the months of greatest

risk. This would help make it possible to generate a better response from health services and a reduction in the number of hospitalisations.

The quality of care in health service establishments also affects the number of deaths and the population's health. The most common is the precariousness of material and professional resources faced by the health area, mainly in Latin American countries. This was observed in this last health crisis, showing how a lack of resources led these centres to a rapid collapse in the face of Covid-19 (GARCIA, 2020; LUCCHESE, 2004; WHO, 2020). Moreover, studies have shown that these deficiencies increase the health risks for patients (CECCHERINI *et al.*, 2016; EBI, 2011; FRUMKIN *et al.*, 2008; VAN LINDEN *et al.*, 2015).

In conclusion, we think it is pertinent to identify the most critical periods for temperature increases, morbidity and mortality of the population in different areas of the country, calling the attention of local and municipal authorities to take actions that guarantee adequate equipment and health care to reduce this health burden which will only be accentuated in the context of climate change.

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Impacto de las olas de calor en la morbilidad y mortalidad cardiovascular y respiratoria en municipios del Nordeste de Brasil

Impact of heat waves on cardiovascular and respiratory morbidity and mortality in municipalities of Northeastern Brazil

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ARTICLE – VARIA

RESUMEN

En los últimos años se generaron un vasto número de estudios sobre impactos que causan las olas de calor sobre la salud de la población, sin embargo, muchos de ellos fuera del país. Este estudio tiene el objetivo de analizar el impacto de olas de calor sobre la salud cardiovascular y respiratoria de la población nordestina, analizando cómo olas de calor de octubre a marzo aumentan los riesgos de morbilidad y mortalidad de la población de cinco municipios. Se observa que los meses de Enero, Febrero y Octubre son los que presentan más casos de morbilidad y mortalidad de la población y que el municipio de Belém del São Francisco presenta la mayor probabilidad de riesgo. Adicionalmente se encontró una señal positiva constante entre las olas de calor y la hospitalización cardiovascular. Se

utilizó un diseño cruzado de casos estratificado para estudiar la asociación entre ola de calor y óbitos e internaciones.

Palabras clave: Olas de calor. Temperatura. Variabilidad. Mortalidad. Morbilidad. Impactos en la salud.

ABSTRACT

In the last few years, a vast number of studies have studied the impacts of heat waves on population health. However, very few have been conducted in Brazil. This study aims to analyze the impact of heat waves on the cardio-respiratory health of the northeastern population, analyzing how heat waves from October to March increase the risks of morbidity and mortality in the population of five municipalities. It is observed that the months of January, February and October are the ones that present more cases of morbidity and mortality of the population and that the municipality of Belém del San Francisco presents the highest odds of increased health risk from heat waves. Additionally, a positive signal was found between heat waves and cardiovascular hospitalizations for many heat wave definitions. A time stratified cross-case design was used to study the association between heat waves and deaths and hospitalizations.

Keywords: Heat waves. Temperature. Variability. Mortality. Morbidity. Health impacts.

1 INTRODUCCIÓN

El aumento de las ondas de calor puede afectar la salud y causar un incremento en muertes (ALCALÁ, 2019; ANDERSON, 2009; ARMSTRONG, 2014; GUO, 2017; NATIONAL, GUERRERO, 2018; PÉRES, 2020). Este hecho quedó evidente después de la intensa ola de calor que afecto 16 países de Europa en 2003 y provoco la muerte de 70,000 personas. Según los estudios realizados por Alcalá (2019), entre los años 2003 y 2018 se ha observado un incremento de la magnitud, duración e intensidad de las olas de calor a nivel global. Los autores muestran que en el año 2018 se registraron olas de calor en Asia, Norte América, Europa y Oceanía provocando 1,500 muertes a nivel global.

El objetivo del presente artículo es analizar el impacto de olas de calor sobre la salud cardiovascular y respiratoria de la población nordestina, analizando cómo olas de calor de octubre a marzo aumentan los riesgos de morbilidad y mortalidad de la población de cinco municipios sobre estas enfermedades. Sobre esto, algunos estudios muestran que la variabilidad de temperatura del aire (TA) y las ondas de calor, inciden en las tasas de morbilidad y mortalidad de la población y, principalmente, de aquellas más vulnerables (ANDERSON, 2009; ARMSTRONG, 2014; BERNAL *et al.*, 2014; GREEN *et al.*, 2015; GUO, 2017; LI *et al.*, 2015). En el Brasil, algunos estudios realizados muestran una asociación entre ondas de calor, temperatura del aire y mortalidad, y otros, factores asociados a características socioeconómicas de la población, provocando mayor vulnerabilidad (GEIRINHAS *et al.*, 2020). Según estos estudios, en diferentes partes del país, la temperatura y humedad tiene una influencia tanto en los indicadores generales de mortalidad, así como en causas específicas. Otros estudios, indican que ondas de calor generan una serie de impactos sobre la salud humana en las regiones estudiadas (BAUTISTA *et al.*, 2011; CARVER; SHEIER, 2014; ERCIDES, 2020; GEIRINHAS *et al.*, 2019; GUO *et al.*, 2015; IKEFUTI, 2018; LAERTE *et al.*, 2016; SILVEIRA *et al.*, 2019).

Silveira *et al.* (2019), investigando el efecto total de temperatura sobre mortalidad cardiovascular en 27 ciudades brasileñas, por ejemplo, demuestra la existencia de riesgos asociados a temperatura y los lugares. Para la autora, la mortalidad cardiovascular está asociada a la baja y alta de temperaturas en la mayoría de las ciudades de Brasil. Zhao *et al.* (2019), cuantificando la relación entre el calor y la hospitalización por épocas del año y las condiciones climáticas de 1642 ciudades durante las estaciones cálidas de 2000-2015, demuestra que el número de hospitalizaciones aumenta a una temperatura media diaria, incrementándose en la estación cálida tardía en comparación con la estación cálida

temprana. El autor resalta que este efecto se registra de manera similar entre mujeres y hombres, sin embargo, incide más en mayores de 75 años.

Laerte *et al.* (2016), evaluando el efecto de la estacionalidad climática en la aparición de síntomas respiratorios en la ciudad tropical de Goiânia (GO), observó que el número de individuos con síntomas respiratorios aumentó significativamente con la reducción de la humedad relativa, incremento, que afirma, podría predecirse a partir del análisis de datos meteorológicos regionales. Por otro lado, Ikefuti (2018) evaluando las asociaciones entre accidente cerebrovascular y temperatura del aire en el periodo 2002 a 2011 en la ciudad de São Paulo, muestra que la temperatura del aire aumentó la mortalidad por derrame cerebral en dicha ciudad tanto en hombres como mujeres.

Analizando el impacto de las ondas de calor sobre la salud cardiorrespiratoria de la población, la Organización Mundial de Salud (OMS) afirma que el clima y sus variaciones abruptas tiene un papel importante sobre la mortalidad y morbilidad de la población (ALCALÁ, 2019; SURVEILLANCE, 2004; WHO, 2014), demostrado que el factor climático se constituye en un factor de riesgo para la salud de poblaciones vulnerables. Se estima que la abrupta variabilidad de temperaturas y el surgimiento de ondas de calor, resultado del cambio climático, provocaría en los próximos años aumentos en mortalidad y morbilidad de la población (ALCALÁ, 2019; SURVEILLANCE, 2004), siendo necesario realizar estudios específicos para poder generar medidas de adaptación y alertas tempranas locales, con la finalidad de generar resiliencia en la población probablemente afectada (CONLON *et al.*, 2011; KINGDOM, 2011). En este sentido, comprender los umbrales más pertinentes para revelar el impacto de olas de calor en la salud es importante, posibilitando activar eficazmente sistemas de alerta temprana y proteger a la población.

Los estudios realizados en Brasil que estudian los impactos del calor en la salud se han centrado predominantemente en las principales ciudades del país, dando poca atención a las ciudades más pequeñas, donde las condiciones sociales y económicas son diferentes.

Por ello es importante realizar estudios en estas áreas para generar datos científicos que contribuyan a la generación de alertas tempranas en estas regiones. Al generar evidencia sobre los factores de riesgo en estas ciudades, las autoridades locales pueden tomar las acciones correspondientes para mejorar los servicios de salud y proteger la salud de la población (LUCCHESE, 2004; MACHADO *et al.*, 2017). Los resultados de la investigación también pueden aumentar el conocimiento de los impactos de los fenómenos climáticos relacionados con la temperatura sobre la morbilidad y la mortalidad en las regiones semiáridas de Brasil, posibilitando la generación de políticas públicas que ayuden a los proveedores de servicios de salud y a la población local a enfrentar mejor estas agravantes de la salud humana.

2 ÁREA DE ESTUDIO

La cuenca de San Francisco en Brasil es considerada una de las más importantes del país, por un lado, porque es una de las más extensas y caudalosas de la región y, por otro, porque tiene una importancia económica, cultural y social relevante, principalmente, para la población asentada en las regiones del Nordeste e Sudeste. Este río tiene una superficie de drenaje de 634.781 km^2, representando el 8% del territorio nacional, abarcando 503 municipios y formando parte de siete Unidades o Estados de la Federación: Bahia, Minas Gerais, Pernambuco, Alagoas, Sergipe, Goiás y el Distrito Federal. La cuenca está dividida en cuatro sub regiones fisiográficas (Alto medio, sub medio, medio y bajo San Francisco) abasteciendo áreas donde sus habitantes conviven con secas prolongadas y aridez extrema (HERMUCHE, 2002).

Cada una de las cuatro regiones fisiográficas de la cuenca se caracterizan por poseer diferentes tipos de clima, suelo y cobertura vegetal. La presente investigación se realizó en algunos municipios que corresponden al Submédio de San Francisco (SubM-SF), cual presenta un clima semiárido y árido y registra una precipitación media anual que oscila entre 800 y 350 mm y una temperatura media anual de

27ºC que, asociada a las 2.800 horas de insolación, da como resultado 1.550 mm de evapotranspiración media anual (MOURA *et al.*, 2006).

El SubM-SF se caracteriza por ser un área donde existe escases de agua, extremos climáticos, precipitaciones impredecibles y alta evapotranspiración (MARENGO *et al.*, 2018; SHUKLA, 1981). En relación a la temperatura máxima y mínimas del área estudiada, estas se dan durante los meses de Noviembre y Julio, respectivamente, registrándose una temperatura máxima de 28,05ºC y 22,89ºC como mínima.

Considerando estos aspectos, la presente investigación analiza el impacto de olas de calor sobre la salud de la población que habita los municipios de Belém do São Francisco, cual cuenta con 20.253 habitantes segundo censo 2010, Floresta con 29.285, Itacuruba con 4.369, Petrolândia con 32.492, Jeremoabo con 37.680 y Paulo Afonso con 108.396 habitantes. Territorios correspondientes a los estados de Bahia y Pernambuco (Figura 1).

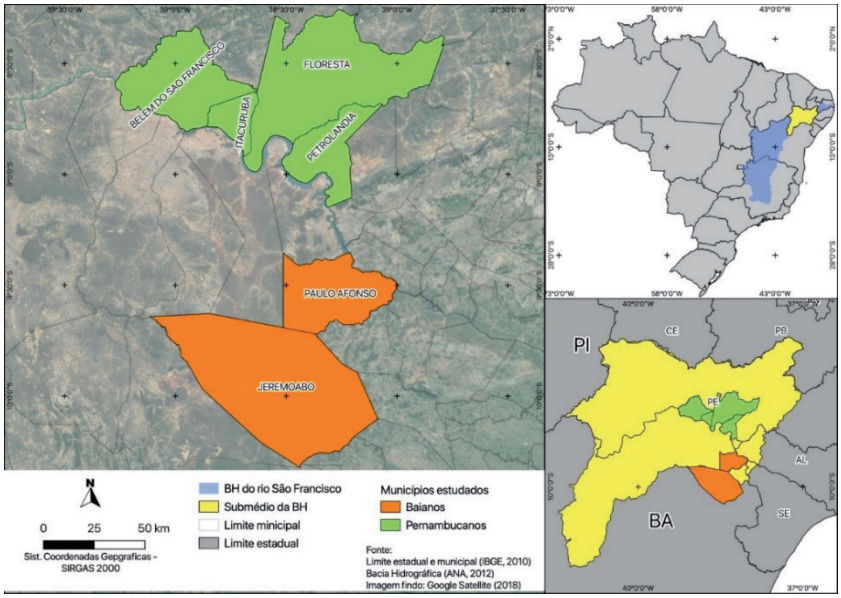

Figura 1 | Mapa del área de estudio en la región Sub medio de San Francisco.

Source: Elaboración de los autores.

3 MÉTODOS

Desde el año 2018 la red Brasilera de Investigación en Cambio Climático (REDE CLIMA por sus siglas en portugués) y el Observatorio de las Dinámicas Socio ambientales (INCT – Odisseia) viene realizando investigaciones de campo junto a pueblos y comunidades tradicionales de la región Sub Medio de la Cuenca de San Francisco, con la finalidad de analizar los impactos que viene provocando el cambio climático sobre la población local.

En este caso, el objetivo de esta investigación fue evaluar el efecto de la estacionalidad climática en la ocurrencia de internaciones y óbitos de pacientes con cuadros de enfermedades cardiovasculares y respiratorias atendidos en una Unidad Básica de Salud local (UBS), (Ver Tabla 1). El estudio fue desarrollado a partir del análisis de datos primarios del periodo (Enero 2008 a Septiembre 2019), cuales fueron facilitados por la Coordinación General de Informaciones y Análisis Epidemiológico (CGIAE), área responsable por el Sistema de Informaciones sobre Mortalidad (SIM) del Ministerio de Salud del Brasil.

En el presente estudio, se define como evento de ola de calor cuando la temperatura máxima excede el umbral del percentil (99, 97.5 o 95) de la distribución de temperatura para cada región, dentro de un mes o temporada específica desde enero 2008 a marzo 2019. Se consideraron para este análisis la ola de calor definida por los días de calor extremo dentro de la temporada de primavera y verano (octubre-marzo). También se crearon definiciones mensuales de olas de calor y se definieron como la temperatura que excede el umbral del percentil por mes, considerando los días de calor extremo dentro de cada mes individual. Todas las definiciones se consideraron como eventos de olas de calor de uno o dos días, que es cuando la temperatura alcanza el umbral del percentil (99, 97.5 o 95) durante dos días consecutivos. Estas diversas definiciones fueron tomadas en cuenta para determinar la medida ideal para eventos de calor extremo, así como, para determinar en qué meses o estaciones se observan las asociaciones más fuertes. No fue incluido septiembre debido a que este mes fue considerando de transición con la estación más fría del año, invierno.

Sobre el análisis estadístico, se utilizó un diseño de casos cruzados time-stratified para estudiar la asociación entre cada definición de ola de calor y óbitos e internaciones de enfermedades cardiovasculares y respiratorias (BASU, 2008; BASU; OSTRO, 2008; TONG, 2012). La metodología se asemeja al diseño y análisis de un estudio de casos y controles, sin embargo, aquí los controles se identifican para el mismo individuo al que de los casos en la población de estudió; por lo tanto, solo las variables que varían con el tiempo se consideran covariables. Los días de control se seleccionaron con base en el mismo día de la semana de ingreso al hospital dentro del mismo mes y año en que ocurrió el caso. Se eligieron percentiles (97.5 y 99) para las definiciones de eventos de olas de calor para este análisis, con el fin de identificar los días de calor extremo.

Se empleó un modelo de regresión logística condicional para estudiar la asociación entre las olas de calor y óbitos e internaciones para cada definición de ola de calor y diagnóstico de hospitalización. Se utilizó la precipitación como covariable para ajustar la humedad, así también, se realizaron análisis de regresión logística condicional para cada definición de ola de calor y diagnóstico de hospitalización para toda la región y municipio.

Adicionalmente y con la finalidad de profundar el estudio, realizamos un análisis de variabilidad climática de los municipios abordados entre el periodo (1989 - 2019). Éste fue realizado con datos satelitales geoespaciales, correspondientes a The Power Project de la Nasa. La fuente de datos primarios solares y meteorológicos facilitados por la NASA, se producen de forma nativa en una cuadrícula global de latitud / longitud de 1 ° x 1 ° y se resignan a una cuadrícula de latitud / longitud de 0.5° x 0.5° mediante interpolación o replicación bilineal (THE POWER PROJECT, 2020). Una vez analizados los datos, estos fueron comparados a otros estudios desarrollados en la región, con la finalidad de confirmar las deducciones obtenidas (GAIVIZZO *et al.*, 2019; MARENGO, 2009; RODRIGUES FILHO, 2016; SILVA *et al.*, 2011; TEIXEIRA, 2016).

Los datos climáticos adquiridos se analizaron asociando el número de muertes y hospitalizaciones de la población local y, los resultados obtenidos en la regresión, podrían informar futuros riesgos relacionados con las olas de calor.

Cabe resaltar que este estudio cumple con las normas y exigencias del Comité de Ética de Investigación de la facultad de Ciencias Humanas y Sociales de la Universidad de Brasilia (UnB), cual está debidamente registrada en el proceso No. 01037218.5.0000.5540 e dictamen de aprobación No. 3.440.596.

4 RESULTADOS

4.1 VARIABILIDAD CLIMÁTICA EN LA REGIÓN ESTUDIADA

Como manifestado existe una serie de trabajos que muestran cómo el factor climático se torna en un agravante para la salud de poblaciones vulnerables, constituyéndose importante conocer y estimar la variabilidad de temperaturas, olas de calor y el número de mortalidad pueden jugar un papel en el aumento de la mortalidad y la morbilidad. Se cree que, como resultado del cambio climático, en los próximos años se registren un aumento y disminución de temperaturas en algunas estaciones del año, generando aumentos en la mortalidad (CONLON *et al.*, 2011; KINGDOM, 2011).

Por lo tanto, se vuelve relevante realizar evaluaciones de estos extremos de temperatura para generar proyecciones de impactos en la salud, así como generar medidas de adaptación que den paso a promover la resiliencia de las poblaciones afectadas.

Analizando la variabilidad de temperatura que abarca el periodo 1989 – 2019 en la región estudiada, se observa un leve incremento en las temperaturas a lo largo de los años, cual llega a (0,5ºC) como media anual (Ver Figura 2). Analizando las temperaturas más bajas, se observa que el año más crítico fue 1989, llegando a 25,42ºC, consecuentemente el más caluroso fue 1998, año en el que se registró 27,08ºC.

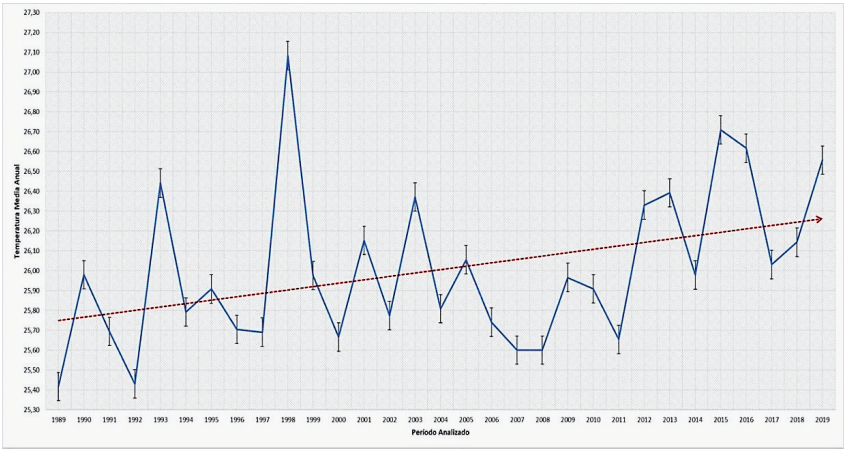

Figura 2 | Variación de la temperatura media anual registrada en el área de estudio entre el periodo 1989 - 2019.

Fuente: Elaboración de los autores, con datos de NASA Prediction of Worldwide Energy Resources (Power). Higher Resolution Daily Time Series by Location 1/2 x 1/2 degree.
Climatology Resource for SSE - Renewable Energy. Bottom-left Latitud: -10.2640 Longitud: -39.0400. Upper-right Latitud: -8.4705 Longitud: -38.0270.

Analizando la temperatura máxima y mínima registrada en el mismo periodo, correspondientes a los meses de Noviembre y Julio, podemos observar con más claridad una elevación en la temperatura media de estos meses (Ver Figura 3). En los primeros años del periodo analizado, se observa que la temperatura media para el mes de noviembre era de 27, 7oC, valor que paso a 28.6ºC en los últimos años, mostrando una elevación de aproximadamente (1ºC).

En relación a la variabilidad de la temperatura más baja registrada en los meses de Julio, de la misma forma, observamos un leve incremento a lo largo del periodo analizado. En los primeros años la media alcanzaba a 22,5ºC, pasando entre 1998 y 2012 a registrarse 23,4ºC.

Dicha variación en la temperatura puede influir en el incremento o declinación del número de casos de morbilidad y mortalidad de la población local, cifras que analizamos a continuación considerando los datos de temperatura expuestos hasta aquí.

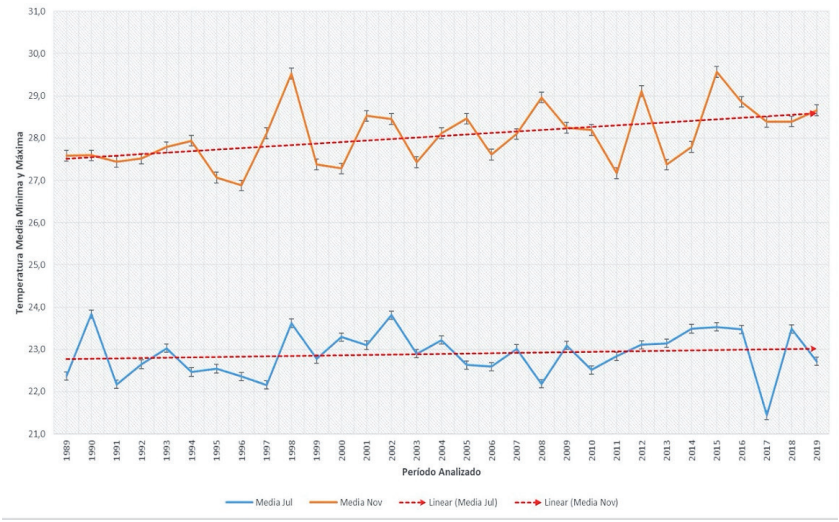

Figura 3 | Variación de la temperatura media máxima regional (noviembre) y variación de la temperatura media mínima (junio) registrada en el área de estudio entre el periodo 1989 - 2019.

Fuente: Elaboración de los autores, con datos de NASA Prediction of Worldwide Energy Resources (Power). Higher Resolution Daily Time Series by Location 1/2 x 1/2 degree.
Climatology Resource for SSE - Renewable Energy. Bottom-left, Latitud: -10.2640 Longitud: -39.0400. Upper-right, Latitud: -8.4705 Longitud: -38.0270.

4.2 OLAS DE CALOR, MORBILIDAD Y MORTALIDAD DE LA POBLACIÓN LOCAL

Nuestra población de estudio incluyó 22,896 hospitalizaciones y 1,265 óbitos en los municipios de Belém do São Francisco, Floresta, Itacuruba, Petrolândia, Jeremoabo y Paulo Afonso, territorios correspondientes a los estados de Bahía y Pernambuco de enero 2008 a septiembre 2019 (Ver Tabla 1).

Tabla 1 | Descripción del total de hospitalizaciones y óbitos por ambas enfermedades. 2008-2019

Municipio	*Hospitalizaciones por ambas enfermedades*	*Óbitos (%)*
Belém de São Francisco	1229 (43.0)	19 (47.4)
Floresta	3491 (43.9)	128 (49.2)
Itacuruba	175 (46.9)	twenty
Jeremoabo	1553 (39.0)	104 (39.4)
Paulo Afonso	12,120 (43.6)	917 (47.3)
Petrolândia	4,328 (42.8)	95 (45.3)
TOTAL	22,896	1,265

Fuente: Elaboración de los autores con datos da Coordinación General de Informaciones y Análisis Epidemiológico (CGIAE).

Tabla 2 | – Descripción de definiciones de olas de calor por periodo de verano

Por periodo de verano				
Temporada	*Definición de ola de calor*	*Percentil umbral y temperatura mediana (°C)*	*Duración (días)*	*Número de días por los municipios*
verano	HWD1	99 (31.7)	1	123
verano	HWD2	99 (31.9)	2	51
verano	HWD3	97.5 (31.3)	1	317
verano	HWD4	97.5 (31.5)	2	155
verano	HWD5	95 (30.9)	1	617
verano	HWD6	95 (31.1)	2	347

Fuente: Elaboración de los autores.

Los umbrales de temperatura para las definiciones de olas de calor y el número que ocurrió se describen en la Tabla 2. El umbral más bajo para la temperatura en todos los municipios tuvo un promedio de 29.9ºC por las olas de calor de dos días definidos al porcentaje 99 en enero. Lo más alto de todas las definiciones de ola de calor fue 32.5ºC por olas de calor de 2 días definidos al porcentaje 97.5 en Noviembre (Ver Tabla 3).

Tabla 3 | – Descripción de definiciones de olas de calor por mes

Por mes				
Temporada	*Definición de ola de calor*	*Percentil umbral y temperatura mediana (°C)*	*Duración (días)*	*Número de días por los municipios*
Octubre	HWD1o	99 (31.2)	1	21
Octubre	HWD2o	99 (32.1)	2	5
Octubre	HWD3o	97.5 (30.9)	1	54
Octubre	HWD4o	97.5 (31.0)	2	21
Octubre	HWD5o	95 (30.5)	1	106
Octubre	HWD6o	95 (30.7)	2	57
Noviembre	HWD1n	99 (32.4)	1	22
Noviembre	HWD2n	99 (32.5)	2	8
Noviembre	HWD3n	97.5 (31.7)	1	50
Noviembre	HWD4n	97.5 (32.5)	2	8
Noviembre	HWD5n	95 (31.3)	1	99
Noviembre	HWD6n	95 (31.5)	2	46
Diciembre	HWD1d	99 (31.6)	1	16
Diciembre	HWD2d	99 (31.0)	2	4
Diciembre	HWD3d	97.5 (31.6)	1	53
Diciembre	HWD4d	97.5 (31.7)	2	23
Diciembre	HWD5d	95 (31.4)	1	107
Diciembre	HWD6d	95 (31.6)	2	65
Enero	HWD1e	99 (30.9)	1	20
Enero	HWD2e	99 (29.9)	2	2

Por mes				
Temporada	*Definición de ola de calor*	*Percentil umbral y temperatura mediana (°C)*	*Duración (días)*	*Número de días por los municipios*
Enero	HWD3e	97.5 (30.5)	1	56
Enero	HWD4e	97.5 (30.7)	2	21
Enero	HWD5e	95 (30.2)	1	117
Enero	HWD6e	95 (30.7)	2	21
Febrero	HWD1f	99 (30.6)	1	20
Febrero	HWD2f	99 (30.6)	2	2
Febrero	HWD3f	97.5 (30.5)	1	49
Febrero	HWD4f	97.5 (30.6)	2	24
Febrero	HWD5f	95 (30.2)	1	96
Febrero	HWD6f	95 (30.4)	2	53
Marzo	HWD1m	99 (31.24)	1	21
Marzo	HWD2m	99 (31.3)	2	9
Marzo	HWD3m	97.5 (30.7)	1	57
Marzo	HWD4m	97.5 (30.8)	2	27
Marzo	HWD5m	95 (30.4)	1	109
Marzo	HWD6m	95 (30.5)	2	63

Fuente: Elaboración de los autores.

Al explorar la asociación entre los días de ola de calor, hospitalizaciones y óbitos, hubo cierta variabilidad, observando una señal positiva entre las olas de calor y la hospitalización cardiovascular, particularmente en las olas de calor de dos días (Ver Figura 4). Los resultados nos muestran principalmente que las olas de calor provocan un efecto mayor sobre la morbilidad cardiovascular, principalmente al día siguiente de la ola de calor y en las olas de calor de dos días. En el caso de morbilidad respiratoria, los datos nos muestran un leve impacto, sin embargo, sin precisión.

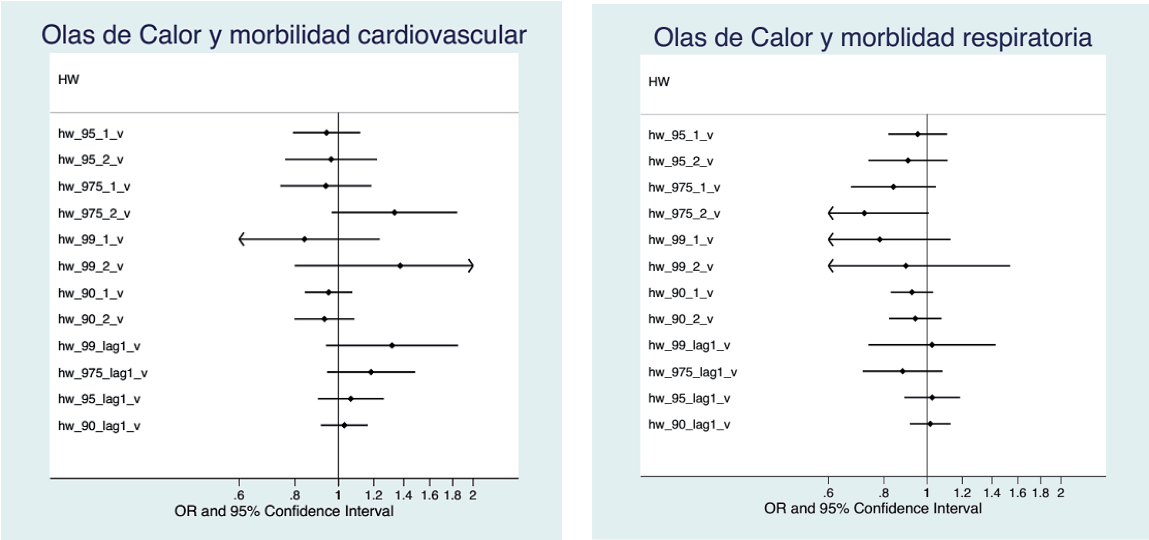

Figura 4 | Impacto de las olas de calor sobre la morbilidad cardiovascular y respiratoria.
Fuente: Elaboración de los autores. Análisis de casos cruzados estratificados.

Debido a que la muestra de óbitos fue pequeña para nuestro análisis, nos enfocamos en hospitalizaciones como resultados primarios. En general, encontramos más impacto por olas de calor definidos por mes que los definidos por todo el periodo. En el mes de enero, por ejemplo, observamos que existe más riesgo de hospitalización en la población cuando se registran olas de calor (Figura 5). Como se puede observar, los efectos de las olas de calor son positivos al inicio en enero, febrero y octubre, meses en los que existiría una mayor probabilidad de hospitalizaciones cardiovascular y respiratoria.

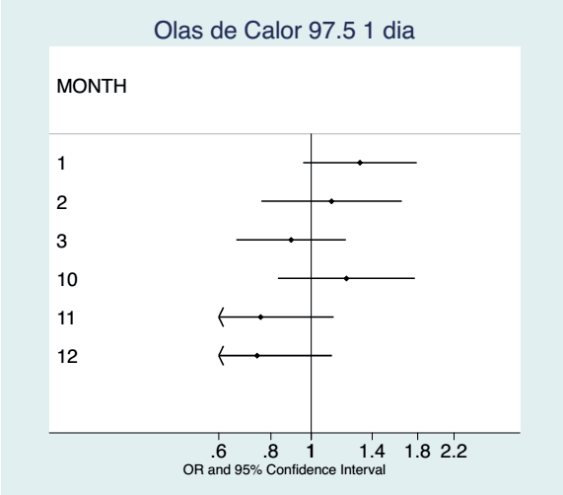

Figura 5 | Impacto por olas de calor definidos por mes por olas de calor de 1 día al porcentaje 97.
Fuente: Elaboración de los autores. Análisis de casos cruzados estratificados.

Considerando los resultados por municipio, observamos que la población más expuesta y propensa a problemas respiratorios y cardiovasculares por olas de calor en estos períodos, se encuentra en el municipio de Belém do Sao Francisco, con una razón de probabilidad de 1,85 (IC 95%: 0,99, 3.43). (Ver Figura 6).

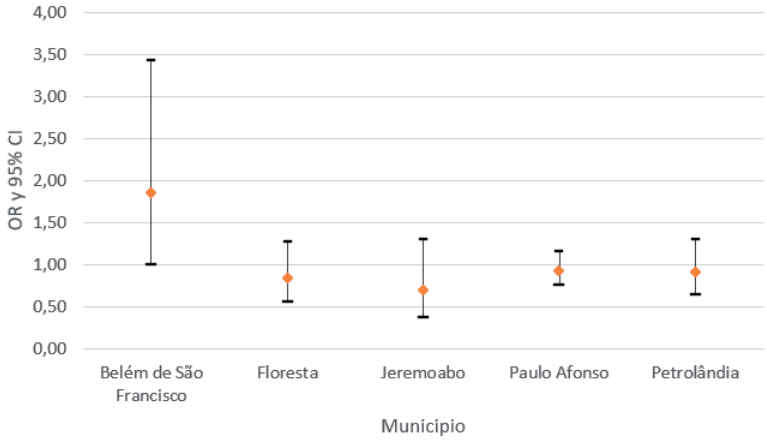

Figura 6 | Efecto de olas de calor por departamento
Fuente: Elaboración de los autores, realizando el análisis de casos cruzados estratificados.

5 DISCUSIÓN Y CONCLUSIÓN

El análisis de los datos de salud obtenidos a nivel municipal nos muestra que olas de calor durante el periodo Octubre a Marzo tienen influencia sobre el número de casos de morbilidad de la población Nordestina, particularmente en Belém do São Francisco. Como recomendación, observando los datos obtenidos, este municipio debe prepararse para responder al aumento de casos conforme se registren incrementos de temperatura en los meses altamente probables.

El análisis de la variabilidad climática regional, nos muestra un incremento de aproximadamente 1ºC durante el periodo 1989 – 2019. Dicho incremento pudo incrementar el número de casos en los últimos años, principalmente en los meses que muestran mayor número de casos, ya que como se observa existe una abrupta elevación y disminución en las temperaturas (Ver Figura 3).

Aparentemente, el aumento de casos en ciertos meses podría estar impulsado por la variación brusca de temperatura y las olas de calor (ANDERSON, 2009; ARMSTRONG, 2014; BAUTISTA *et al.*, 2011; CARVER; SHEIER, 2014; GEIRINHAS *et al.*, 2019; GUO, 2017; GUO *et al.*, 2015; IKEFUTI, 2018; SILVEIRA *et al.*, 2019). Por ejemplo, Silveira *et al.*, (2019), observó un efecto de la temperatura y las olas de calor sobre la mortalidad cardiovascular en 27 ciudades brasileñas.

Los factores socioeconómicos o fisiológicos pueden aumentar la vulnerabilidad al calor extremo, por lo que es fundamental promover políticas que apunten a reducir los riesgos existentes en relación con los servicios de salud y las disparidades socioeconómicas (ERCIDES, 2020; SARRÓ, 2009). Las características de habitabilidad, trabajo y dinámica de la población, en relación a la ocupación de espacio como de asentamientos ilegales donde la improvisación de acceso a servicios básicos es común, también aumentan su riesgo en salud incrementando la vulnerabilidad a los factores climáticos estresantes (YANG, el al., 2019).

Este punto no pudo ser evaluado en la presente investigación, debido al objetivo y los datos analizados, sin embargo, consideramos que sería de gran utilidad analizarlos en futuros trabajos ya que ayudarían de mejor manera a ver los efectos de las olas de calor sobre la salud poblacional. Una de las limitantes con las que se atravesó, fue la poca existencia de estudios realizados en el Brasil y en la región, por lo que se considera necesario generar mayor evidencia epidemiológica para corroborar lo afirmado y disminuir la vulnerabilidad de la población afectada. Adicionalmente la obtención de datos de mortalidad y morbilidad por municipios fue otra limitante, restringiendo el estudio a realizarlo apenas en seis de quince municipios que se solicitó información.

Es esencial pensar en registrar y difundir datos que ayuden a realizar este tipo de análisis y encontrar solución a estas incertezas, así como en el establecimiento de alertas tempranas regionales y municipales, con énfasis en los meses de mayor riesgo. Esto ayudaría a generar una mejor respuesta de los servicios de salud y una reducción en el número de hospitalizaciones.

La calidad de la atención en los establecimientos de servicios de salud también influye en el número de muertes y en la salud de la población. Entre los más comunes está la precariedad de recursos materiales y profesionales que enfrenta el área de la salud, principalmente en los países de América Latina. Así se observó en esta última crisis sanitaria, mostrando cómo la falta de recursos llevó a estos centros a un rápido colapso frente al Covid-19 (GARCIA, 2020; LUCCHESE, 2004; OMS, 2020). Los estudios han demostrado que estas deficiencias aumentan los riesgos para la salud de los pacientes (CECCHERINI *et al.*, 2016; EBI 2011; FRUMKIN *et al.*, 2008; VAN LINDEN *et al.*, 2015).

En conclusión, consideramos pertinente identificar los periodos más críticos para el aumento de temperatura, morbilidad y mortalidad de la población en las diferentes zonas del país, llamando la atención de las autoridades locales y municipales para tomar acciones que garanticen el adecuado equipamiento y atención en salud para reducir esta carga que solo se acentuará en el contexto del cambio climático.

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Whale-watching in Brazil

Turismo de observação de cetáceos no Brasil

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ABSTRACT

This study aimed to investigate whale-watching in Brazil by surveying its areas of occurrence, key species, and current guidelines and regulations. The methodology includes a bibliographic search of cetacean occurrence and whale-watching areas in Brazil, legal instruments, and codes of conduct regulating this activity. A search for whale-watching areas was carried out on the homepage of tourist agencies and operators. In addition, data were collected via telephone, email, and social media of the tourist agencies and operators. In this study, we identified seven cetacean species and 29 whale-watching areas, 79% of which are protected areas. The results of this study may help monitor and enforcement measures for whale-watching aimed at protecting these animals.

Keywords: Whale. Ecotourism. Dolphin. Aquatic mammals. Protected areas.

RESUMO

Este estudo pretendeu investigar o turismo de observação de cetáceos no Brasil a partir de um levantamento de suas áreas de ocorrência, espécies-chave, e normas e regulamentos vigentes. A metodologia inclui uma pesquisa bibliográfica sobre áreas de ocorrência de cetáceos no Brasil, turismo de observação, instrumentos legais e códigos de conduta para o ordenamento dessa atividade. Foi realizada uma busca por áreas de referência do turismo de observação de cetáceos em homepage de agências e operadoras de turismo. A coleta de dados se deu por meio de contato telefônico, e-mail e redes sociais das agências e operadoras de turismo. Neste estudo, foram identificadas sete espécies de cetáceos-chave do turismo de observação, 29 áreas de referência, com 79% dessas áreas inseridas em Unidades de Conservação.

Os resultados deste estudo poderão subsidiar ações de monitoramento e fiscalização do turismo de observação de cetáceos, visando seu ordenamento e a proteção desses animais.

Palavras-chave: Baleia. Ecoturismo. Golfinho. Mamíferos aquáticos. Unidades de conservação.

1 INTRODUCTION

In Brazil, whale-watching originated in the 1980s in Fernando de Noronha, Pernambuco state (PE), with the spinner dolphin, *Stenella longirostris*, and the Amazonas state (AM) with the Amazon River dolphin, *Inia geoffrensis* (VIDAL *et al.*, 2017). Currently, other cetacean species are crucial to whale-watching in Brazil, such as the Guiana dolphin, *Sotalia guianensis* (LUNARDI *et al.*, 2017), humpback whale, *Megaptera novaeangliae* (FERNANDES; ROSSI-SANTOS, 2018) and the southern right whale, *Eubalaena australis* (GROCH, 2018). In addition, this activity may produce economic benefits by creating jobs and income for the local population (LUNARDI *et al.*, 2017) and environmental and educational benefits by protecting natural resources and promoting tourist awareness (GARCÍA-CEGARRA; PACHECO, 2017; TISCHER *et al.*, 2018).

Although there are some benefits from whale-watching, biodiversity conservation and socioeconomic sustainability are not always achieved. When motorized boats are involved, whale-watching has often been associated with adverse effects (MACEDO *et al.*, 2020). According to the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species, five cetacean species and 19 subspecies are critically endangered worldwide, while 12 species and 12 subspecies are endangered (IUCN, 2022). Four of these endangered species are key to whale-watching in Brazil: the southern right whale, Amazon River dolphin, tucuxi, *Sotalia fluviatilis*, and Guiana dolphin (MMA, 2022).

For whale-watching control, some countries enact specific legislation. For example, in Australia, the activity has been regulated since 2000 by Law nº 181/2000, which governs environmental protection and biodiversity conservation, with a chapter dedicated to cetacean interaction and watching (AUSTRALIA, 2000). In New Zealand, the Marine Mammal Protection Regulation (MMPR), enacted in 1988 and updated in 1992 and 2008, establishes adequate whale-watching conditions, boat approaches, and other interaction guidelines for marine mammals (NEW ZEALAND, 1992). In the Azores, Portugal, whale-watching is regulated by regional Decree nº 10, of March 22, 2003/A, aimed at protecting and conserving cetaceans and promoting tourism development and management (AÇORES, 2003). In Chubut, Argentina, whale-watching is regulated by Law nº 5.714, of December 21, 2007, which forbids approaching and following the southern right whale, and Decree nº 167, of February 29, 2008, which establishes the technical aspects allowed and prohibited for transport services (CHUBUT, 2008). In Brazil, Law nº 7.643, of December 18, 1987, prohibits cetacean hunting in Brazilian jurisdictional waters (BRASIL, 1987), while Ibama (Brazilian Federal Environmental Agency) Ordinance nº 117 of December 26, 1996, updated by Ordinance nº 24 of February 8, 2002, forbids cetacean molestation and establishes limits for boats that operate in Brazilian jurisdictional waters (IBAMA, 2002).

Although whale-watching is an instrument to promote environmental conservation and an important source of employment and income, there are no studies describing how this activity occurs in Brazil's main cetacean concentration areas. Therefore, this study aims to answer two questions: (i) What are the whale-watching reference areas in Brazil and their main key species? (ii) How is whale-watching conducted in Brazil? The results presented here, such as the distribution of reference areas, key whale-watching species in Brazil, and the variables to consider in a comprehensive judicial instrument, may contribute to a national whale-watching enforcement plan to promote cetacean conservation and sustainable ecotourism.

2 METHODOLOGY

Brazil has one of the longest coastlines in Latin America, at more than 7400 km long, and its coastal waters, contiguous zone, and exclusive economic zone exceed 3.4 million km² (NOTHEN, 2015). In addition, Brazil owns some oceanic and fluvial islands that include island complexes (IBGE, 2011).

Since 2008, via Decree nº 6.698, of December 17, 2008, Brazilian jurisdictional waters were declared a whale and dolphin sanctuary, allowing scientific research and sustainable tourism (BRASIL, 2008). As a result, fifty-nine cetacean species have been recorded in Brazil (ICMBIO, 2019) along a coastal zone extending for more than 7400 km (NOTHEN, 2015), in a marine zone, and inland waters.

To identify and describe the main whale-watching areas in Brazil, a broad bibliographic search (SOUSA *et al.*, 2021) was conducted in these areas and a documental analysis of legal instruments and codes of conduct from July 2020 to June 2022. In addition, we included scientific articles and book chapters published in the last 30 years, in Portuguese, English, and Spanish, on the Capes platform (www.periodicos.capes.gov.br), Scielo (www.scielo.br), ScienceDirect (www.sciencedirect.com) and Google Scholar (scholar.google.com.br) databases, in addition to legal instruments disseminated on government platforms. The data obtained in this study were analyzed according to the documental analysis approach (CECHINEL *et al.*, 2016), which started with the assessment and preliminary examination of each legal instrument from the standpoint of elements such as the administrative sphere of the protected areas, key species, and whale-watching planning variables.

In addition, a search for whale-watching information was conducted on the homepage of tourist agencies and operators and via telephone contact, email, and social media. Whale-watching was considered a commercial activity, offering a service for tourists to observe one or more cetacean species in their natural environment. Therefore, whale-watching reference areas were those whose information on tour sales is available on the online platforms of tourist agencies or published in scientific articles. The following were recorded to describe whale-watching in Brazil: (i) area, municipality, and state of occurrence of the activity; (ii) key whale-watching species; (iii) whale-watching takes place in a protected area; (iv) observation platform; (v) legal instrument in force; (vi) duration of the tour; (vii) tour cost (R$) and (viii) existence of lectures or other types of environmental communication, before or during the tour. Restrictive measures were also registered in the case of the current legal instrument in the area aimed at enforcing whale-watching.

Whale-watching data in Brazil were grouped and submitted for comparative analysis. It is important to note that although there are different areas of cetacean concentration in Brazil, some do not have local commercial operators, or information on their activities is unavailable online and therefore not included in this study. This is the case for humpback whale watching in the Fernando de Noronha Archipelago (PE) and the south coast of Rio Grande do Norte state (RN).

3 RESULTS

In Brazil, whale-watching focuses on two whales and five dolphin species and occurs in 26 municipalities in 11 Brazilian states and four regions (Table 1). The humpback whale, for example, can be observed on the coast of Salvador, Mata de São João, Porto Seguro, Ilhéus, Itacaré and Caravelas, and the Abrolhos Archipelago, all in Bahia state, as well as on the south coast of Rio Grande do Norte state (RN), the coast of Vitória, Espirito Santo state (ES) and the Alcatrazes Archipelago, in São Paulo state (SP). The southern right whale can be observed on Garopaba, Imbituba, and Laguna's coast in Santa Catarina state (SC). Among the dolphin species is the Guiana dolphin, which can be seen on the coast of Fortaleza, Ceará state (CE) and Tibau do Sul (Figure 1), Nísia Floresta and Baía Formosa (RN), and on the coast of Ilhéus, Caravelas and Jandaíra (BA). Guiana dolphin watching occurs on the coast of Mangaratiba, Guapimirim and Paraty, Rio de Janeiro state (RJ), and in Cananéia (SP), Paranaguá and Guaraqueçaba, Paraná state

(PR), and on the coast of Governador Celso Ramos and São Francisco do Sul (SC). The spinner dolphin is often observed in the Fernando de Noronha Archipelago (PE), and the bottlenose dolphin, *Tursiops truncatus*, in Laguna (SC). In addition, the Amazon River dolphin is key to whale-watching in Manaus and Novo Airão, Amazonas state (AM), and Santarém, Pará state (PA), while the tucuxi can be seen in Santarém (PA), and the Mamirauá Reserve for Sustainable Development in Tefé (AM) (Figure 2).

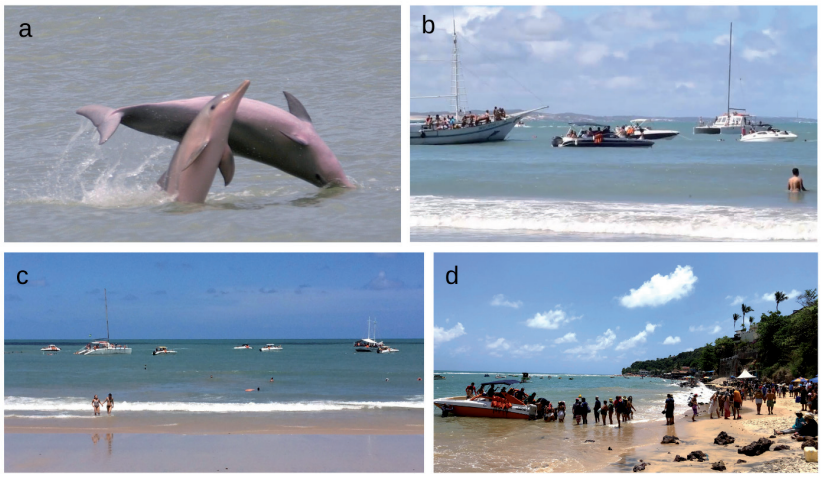

Figure 1 | Guiana dolphin, Sotalia guianensis, watching (a), Coastal Wildlife Reserve of Tibau do Sul (Refauts) (RN), Brazil, where five (b) and seven (c) boats operate in the Restricted Use Zone. Tourist boarding area (d).
Source: LUNARDI, D. G.; LUNARDI, V. O., 2021.

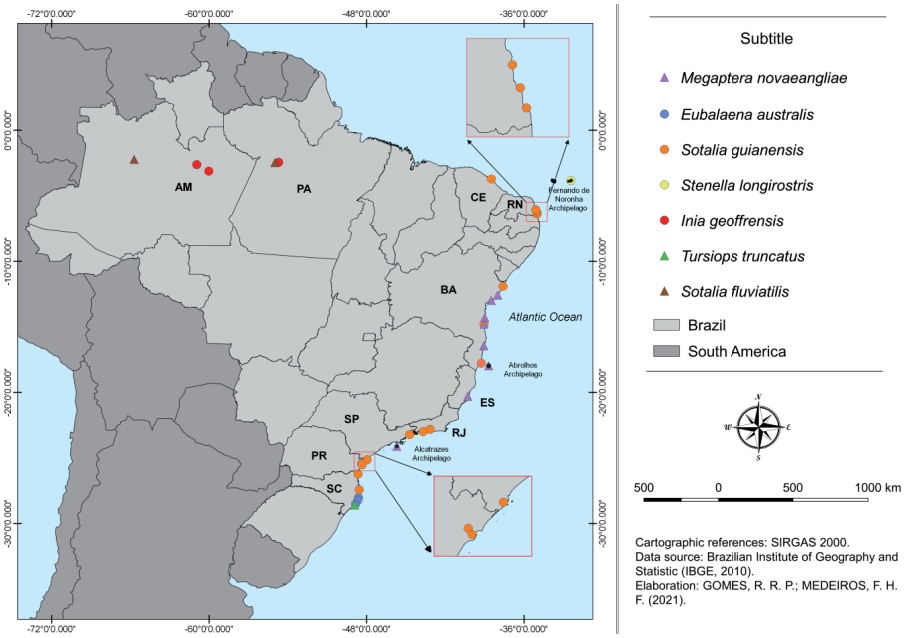

Figure 2 | Reference areas of whale-watching in Brazil.

Source: GOMES and MEDEIROS, 2021.

Of the 29 reference areas of whale-watching, 23 (79%) include a legally protected area, 10 federal, 10 states, and four municipal (Table 1 and 2). It is important to note that the Guaraqueçaba Environmental Protection Area (EPA) includes two municipalities in Paraná state: Paranaguá and Guaraqueçaba. The protected areas indicated in this study are for Sustainable Use (n=17) and Integral Protection (n=4), belonging to the Brazilian System of Protected Areas (Snuc) (BRASIL, 2000a), designed as an EPA (n=13), National Park (n=3), Extravist Reserve (n=2), Wildlife Reserve (n=1), Sustainable Development Reserve (n=1) and Wildlife Refuge (n=1), created by a law or Decree, starting in 1981.

Table 1 | Whale-watching reference areas in Brazil. Marine National Park (MNP). Environmental Protection Area (EPA). Extravist Reserve (ER). Wildlife Refuge (WIREF). MD: Municipal Decree. SD: State Decree. FD: Federal Decree.

Species	*Area*	*State*	*Protected Area?*	*Legal instrument of the Protected Area*
Megaptera novaeangliae	Salvador	BA	no	—
	Abrolhos	BA	Abrolhos MNP	FD nº 88.218/1983
	Mata de São João	BA	Litoral Norte do Estado da Bahia EPA	SD nº 1.046/1992
	Porto Seguro	BA	Marinha do Corumbau ER	FD s/n 2000
	Ilhéus	BA	Lagoa Encantada e Rio Almada EPA	SD nº 2.217/1993 modified by SD nº 8.650/2003
	Itacaré	BA	no	—
	Vitória	ES	Baía das Tartarugas EPA	MD nº 17.342/2018
	Arquipélago de Alcatrazes	SP	Arquipélago de Alcatrazes WIREF	FD s/n 2016
Eubalaena australis	Imbituba	SC	Baleia Franca EPA	FD s/n 2000

Source: Prepared by the authors, 2022.

Table 2 | Whale-watching reference areas in Brazil. Wildlife Reserve (WR). Environmental Protection Area (EPA). Marine National Park (MNP). National Park (NP). Extravist Reserve (ER). Sustainable Development Reserve (SDR). MD: Municipal Decree. SD: State Decree. FD: Federal Decree. ML: Municipal Law.

Species	*Area*	*State*	*Protected Area?*	*Legal instrument of the Protected Area*
Sotalia guianensis	Fortaleza	CE	no	—
	Tibau do Sul	RN	Tibau do Sul WR	MD nº 14/2006 modified by Law nº 616/2018
	Nísia Floresta	RN	Bonfim-Guaraíra EPA	SD nº 14.369/1999
	Baía Formosa	RN	no	—
	Ilhéus	BA	Lagoa Encantada e Rio Almada EPA	SD nº 2.217/1993 modified by SD nº 8.650/2003
	Caravelas	BA	Ponta da Baleia EPA	SD n° 2.218/1993
	Jandaíra	BA	Mangue Seco EPA	SD nº 605/1991
	Mangaratiba	RJ	Boto-cinza EPA	ML nº 940/ 2014
	Guapimirim	RJ	Guapi-Mirim EPA	FD nº 90.225/1984
	Paraty	RJ	Baía de Paraty EPA	ML nº 685/1984
	Cananéia	SP	Cananéia-Iguape-Peruíbe EPA	FD nº 90.347/1984
	Paranaguá	PR	Guaraqueçaba EPA	FD nº 90.883/1985
	Guaraqueçaba	PR	Guaraqueçaba EPA	FD nº 90.883/1985
	São Francisco do Sul	SC	no	—
	Governador Celso Ramos	SC	Anhatomirim EPA	FD nº 528/1992

Species	*Area*	*State*	*Protected Area?*	*Legal instrument of the Protected Area*
Stenella longirostris	Fernando de Noronha	PE	Fernando de Noronha MNP	FD nº 96.693/1988
Tursiops truncatus	Laguna	SC	Baleia Franca EPA	FD s/n 2000
Inia geoffrensis	Novo Airão	AM	Anavilhanas NP	FD nº 86.061/1981 modified by Law nº 11.799/2008
	Manaus	AM	no	—
	Santarém	PA	Tapajós-Arapiuns ER	FD s/n 1998
Sotalia fluviatilis	Tefé	AM	Mamirauá SDR	SD nº 12.836/1990 modified by Law nº 2.411/1996
	Santarém	PA	Tapajós-Arapiuns ER	FD s/n 1998

Source: Prepared by the authors, 2022.

Most whale-watching tours in Brazil occur on vessels such as schooners, catamarans, and motorboats, but whale-watching can also occur from the beach, lookout points, and floating platforms, such as the floating platform of Novo Airão (AM), used to view the Amazon River dolphin. The cost of whale-watching varies from R$ 30.00 to R$ 458.00 (US$ 5.50 to 84.50), depending on the area, duration of the tour, and infrastructure available to tourists. It is important to note that these values were obtained from tour operators between January and June 2022 (Table 3). Humpback whale watching occurs from May to October, while the southern right whale season is from July to November since both species are migratory. For dolphin-watching, tours occur daily or weekly throughout the year (Table 3).

Table 3 | Description of whale-watching in Brazil. *The tour is not sold separately and includes lodging and meals.

Key species	*Area*	*Platform*	*Cost (R$)*	*Duration (min.)*	*Season*
Megaptera novaeangliae	Salvador	boat	300,00	240	July - Oct.
	Abrolhos	boat	458,00	300	
	Mata de São João	boat	280,00	300	
	Porto Seguro	boat	250,00	240	
	Ilhéus	boat	250,00	240	
	Itacaré	boat	250,00	240	
	Vitória	boat	360,00	480	
	Alcatrazes Archipelago	boat	450,00	540	May - Aug.
Eubalaena australis	Imbituba	observation point	200,00	240	July - Nov.

Key species	Area	Platform	Cost (R$)	Duration (min.)	Season
Sotalia guianensis	Fortaleza	boat	40,00	120	Jan. - Dec.
	Tibau do Sul	boat	60,00	50	
	Nísia Floresta	observation point	50,00	120	
	Baía Formosa	boat	40,00	60	
	Ilhéus	boat	250,00	300	
	Caravelas	boat	120,00	180	
	Jandaíra	boat	150,00	120	Nov. - May
	Mangaratiba	boat	150,00	90	Jan. - Dec.
	Guapimirim	boat	150,00	150	
	Paraty	boat	100,00	300	
	Cananéia	boat	50,00	360	
	Paranaguá	boat	100,00	240	
	Guaraqueçaba	boat	100,00	180	
	São Francisco do Sul	boat	80,00	240	
	Governador Celso Ramos	boat	125,00	300	
Stenella longirostris	Fernando de Noronha	boat	450,00	300	
		observation point	147,00	120	
Tursiops truncatus	Laguna	observation point	300,00	180	
Inia geoffrensis	Novo Airão	floating platform	30,00	60	
		boat	120,00	180	
	Manaus	floating platform	160,00	360	
	Santarém	boat	120,00	60	
Sotalia fluviatilis	Tefé	boat	*	240	
	Santarém	boat	120,00	60	

Source: Prepared by the authors, 2022.

Of the 29 reference areas, in at least 17, whale-watching has partnerships with research projects or institutions, favouring the presentation of lectures before or during the tour. Of these, 16 conduct lectures during the whale-watching tours, but only three operators in the Abrolhos, Ilhéus, and Jandaíra reference areas contain whale-watching codes of conduct on their homepage to ensure the well-being of these animals.

Eight of the 29 reference areas contain legal whale-watching enforcement instruments (Table 4). These legal instruments restrict the speed, duration of the tour, type of manoeuvre, and several simultaneous boats in the cetacean concentration area. Ordinance ICMBio/MMA nº 1.112, of December 17, 2018, regulates tourist activities in the Baleia Franca EPA, with headquarters in Imbituba (SC), but whale-watching also occurs in Laguna and Garopaba, both located on the migratory route of this species. It is important to note that southern right whale-watching has been suspended since 2013, as determined by the Federal Justice Court of Laguna (SC). Since then, watching has occurred from the coast (TRF4, 2013).

Table 4 | Legal instruments that enforce whale-watching in Brazil. *Distance between boat and cetacean.

Species *Legal instrument*	*Distance**	*Boat speed*	*Observation time*	*Prohibited manoeuvre*	*Max. nº of boats*
Mysticeti, *Physeter macrocephalus,* and *Orcinus orca* Ordinance nº 24/2002 (IBAMA, 2002)	100 m	—	30 min.	persecution	02
Eubalaena australis Ordinance nº 1.112/2018 (ICMBio, 2018)	≥120 m	≤5 knots	≤30 min.	persecution or interruption of travelling	02
Sotalia guianensis Law nº 349/2007 (Tibau do Sul-RN, 2007)	≥50 m	≤4 knots	≤20 min.	approach or persecution	01
Sotalia guianensis Law n° 832/2012 (MANGARATIBA-RJ, 2012)	—	—	—	—	02
Sotalia guianensis Law nº 2.129/2011 (Cananéia-SP, 2011)	≥50 m	low speed ≤500 m of dolphin	≤30 min.	change of direction, approach, or persecution	02
Sotalia guianensis Law nº 3833/2019 (PARANAGUÁ-PR, 2019)	≥50 m	low speed ≤500 m of dolphin	≤30 min.	change of direction, approach, or persecution	02
Sotalia guianensis Ordinance nº 5-N/1998 (IBAMA, 1998)	—	≤2 knots	≤15 min.	persecution and circular movements	02
Stenella longirostris Ordinance nº 5-N/1995 (IBAMA, 1995)	≥200 m	≤5 knots	—	persecution	02
Inia geoffrensis Regulation nº 28/2018 (CEMAAM, 2018)	≥100 m	≤5 knots	≤15 min.	change or interruption of travelling	—

Source: Prepared by the authors, 2022.

4 DISCUSSION

Of the 59 cetacean species in Brazilian waters (ICMBIO, 2019), at least seven are key to whale-watching, recorded in fluvial waters and widely distributed along the coast, extending from Santa Catarina to Ceará. In Brazil, this activity occurs predominantly in protected areas. Of the 29 whale-watching reference areas, 23 included protected areas, most of the sustainable use. The EPA category is the most common among sustainable use protected areas with whale-watching. EPA aims to protect biological diversity, regulate occupation and ensure sustainable use of natural resources (BRASIL, 2000a). However, considering the current conservation status of some cetacean species, EPA may not be the most adequate protected areas category to protect these animals, given that they allow the direct use of natural resources. Endangered species, such as the southern right whale or Guiana dolphin (MMA, 2022), should be protected by protected areas that restrict human occupation and anthropic activities, such as Wildlife Reserves and Sustainable Development Reserves, which only allow sustainable management of natural resources (BRASIL, 2000a).

Currently the southern right whale has only the Baleia Franca EPA to protect its habitat (BRASIL, 2000b), while part of the geographic distribution area of the Guiana dolphin is protected by the Boto-cinza EPA (RJ) (MANGARATIBA-RJ, 2014), Cananéia-Iguape-Peruíbe EPA (SP) (BRASIL, 1984) and Bonfim-Guaraíra EPA (RN) (RIO GRANDE DO NORTE, 1999).

Many legally protected whale-watching reference areas are located in Bahia, likely due to its extensive coastal zone. However, Santa Catarina harbours the largest number of key whale-watching species, including the southern right whale (RENAULT-BRAGA *et al.*, 2018), bottlenose dolphin (AGRELO *et al.*, 2019), and Guiana dolphin (MACEDO *et al.*, 2020). The Guiana dolphin is the key species with the largest number of whale-watching reference areas in Brazil, occurring in 48% of the areas, due to its coastal habitat and wide geographic distribution, extending from the Atlantic coast of South and Central America to Honduras (SECCHI; SANTOS; REEVES, 2018).

Most protected areas in Brazil that include whale-watching in their territory are federally managed, with only four under municipal administration: Coastal Wildlife Reserve of Tibau do Sul, Baía das Tartarugas EPA, Boto-cinza EPA, and Baía de Paraty EPA. Unlike municipal protected areas, environmental management in federally controlled areas has a greater specialized organizational structure. For example, the Marine National Park of Fernando de Noronha has a platform containing all its information (www.parnanoronha.com.br), which includes access guidelines, tourist attractions, and legal instruments, such as the Ordinance that instituted the Center for Integrated Management of Fernando de Noronha.

The integrated management of ICMBio Noronha aims at more effective biodiversity conservation and the creation of protected areas, acting as the only consultive council (ICMBIO, 2017). In addition, the Marine National Park of Fernando de Noronha contains an agency that supports public visitation and visitor fee collection.

Unlike the Marine National Park of Fernando de Noronha, the municipally managed Coastal Wildlife Reserve of Tibau do Sul (Refauts) has no facilities for the sustainable management of natural resources, visitor reception, or online platform to allow access to information on the Refauts or Guiana dolphin watching. In this respect, many people who visit the Refauts and take the Guiana dolphin-watching tour are unaware that this species is endangered or that this area is a Wildlife Reserve (SILVA *et al.*, 2021). Furthermore, more than ten years after its creation, management of the Refauts remains inadequate, given the absence of a specialized administrative agency.

In June 2021, the Federal Public Ministry issued Recommendation 06/2021 to create an interinstitutional group; devise strategies to stop the slaughter of Guiana dolphins in Tibau do Sul (RN); develop a plan to monitor fishing activities and whale-watching; carry out a technical study to control fishing activities; conduct a dissemination and environmental awareness campaign and provide a continuous environmental conservation training course for social actors (MPF, 2021).

The creation of protected areas that include cetacean concentration areas in Brazil dates from 1981, with the establishment of the Anavilhanas Reserve (AM), which became the Anavilhanas National Park – an important Amazon river dolphin protection area (BRASIL, 2008). Most protected areas were created in the 1980s and 90s and included whale-watching reference areas, contrasting with the last decade, when only three new protected areas were established in the country. The last protected area was instituted in 2018 with the creation of the Baía das Tartarugas (Turtle Bay) EPA, which protects a small part of the geographic distribution area of the humpback whale (VITÓRIA-ES, 2018). Since 2019, no new protected area has been created to protect key whale-watching species in Brazil, although they are urgently needed.

At least six whale-watching reference areas are still not legally protected: Salvador and Itacaré (BA) for humpback whale watching; Fortaleza (CE); Baía Formosa (RN), and São Francisco do Sul (SC) for Guiana

dolphin watching, and Manaus (AM), for the Amazon river dolphin. The absence of legal protection in these areas may compromise cetacean conservation, especially endangered species, given that they are more exposed to the negative effects caused by whale-watching (KASSAMALI-FOX *et al.*, 2020; MAREGA-IMAMURA *et al.*, 2018). Therefore, these animals' protection and long-term sustainability require new protected areas that focus on controlling tourist activities and conserving endangered species.

Whale-watching is a significant financial resource, providing higher income than that other tourist activities (SOTO-CORTÉS; ACOSTA; MAYA, 2021). The economic benefits of whale-watching include job creation and an annual income of millions of dollars for the sector (GUIDINO *et al.*, 2020). The cost of these tours in Brazil varies due to their duration, infrastructure, and other tourist attractions, but prices seem similar to those charged by neighbouring countries. For example, in Colombia, 12-hour humpback whale watching tours in the Uramba Bahía Málaga National Park cost around R$ 600.00 (≈US$ 110.00) (grancolombiatours.com) in June 2022. In Brazil, reference areas such as the Abrolhos, Alcatrazes, and Fernando de Noronha archipelagos are costly to maintain, likely because they are difficult to access and exhibit high species richness and degree of conservation of their natural areas (DUTRA *et al.*, 2006).

Although most whale-watching tours occur from boats, there are reference areas where watching is also possible from the coast, on a stretch of beach, or from a lookout point - a feasible and environmentally more adequate alternative since it reduces the negative environmental impacts caused by motorized boats (TISCHER *et al.*, 2020). For example, until 2013, southern right whale watching occurred mainly from motorized boats but was suspended (TRF4, 2013) due to the negative impacts they may cause to this endangered species (CHALCOBSKY; CRESPO; COSCARELLA, 2020).

Southern right whale watching currently occurs on Imbituba, Laguna, and Garopaba (SC) coast. Although fixed platforms reduce the negative impacts, they can also be used inadequately. For example, in Novo Airão (AM), Amazon river dolphins have exhibited behavioural changes due to feeding (ALVES *et al.*, 2013) from floating platforms (CEMAAM, 2018). However, in 2010, after Dolphin Tourism Enforcement (GT Botos in Portuguese) was implemented, a series of initiatives reduced the negative effects of this activity, with the publication of Ordinance nº 47 of April 9, 2012, which established guidelines for visiting the Anavilhanas National Park that prohibit tourists from feeding the dolphins (CEMAAM, 2018).

Whale-watching may be an opportunity to make tourists aware of the importance of environmental conservation (GARCÍA-CEGARRA; PACHECO, 2017), in addition to promoting economic benefits, such as job creation and income generation (LUNARDI *et al.*, 2017) and their environmental counterparts, such as landscape protection (BRUMATTI, 2013). Although this activity is an opportunity to broaden scientific studies, disseminate information on cetaceans, and promote tourist awareness (FERNANDES; ROSSI-SANTOS, 2018), a little more than half of the whale-watching reference areas in Brazil are supported by research projects or institutions, which contribute with lectures, training or provide ecological and biological data on key species. Reference areas supported by research institutions or projects generally impose whale-watching codes of conduct, whereby tourism in these areas may have fewer negative impacts on the species observed (TISCHER *et al.*, 2017). Tourist satisfaction increases when the tour includes educational components and the boat operators comply with the regulations (SITAR *et al.*, 2017).

In Brazil, Law nº 7.643, of December 18, 1987, was the first to protect cetaceans, banning hunting these animals in Brazilian jurisdictional waters (BRASIL, 1987). Ibama Ordinance nº 2.306, of November 22, 1990, subsequently reformulated by Ordinance nº 117, of December 26, 1996, established a minimum distance of 100 m between a motorized boat and any whale species, minimum altitude of 100 m between aircraft and cetaceans; maximum whale-watching time of 30 min; a minimum distance of 50 m to dive or swim near any whale species; and guidelines for tour boats operating in protected areas (IBAMA, 1990; IBAMA, 1996).

Ordinance nº 24, of February 8, 2002, stipulated that boats must keep their motors in the idle position during humpback whale watching and idle or turned off for other cetacean species. It also established a limit of two boats that can simultaneously approach an individual or group of whales (IBAMA, 2002).

In general, the distance between boats and cetaceans established in Brazilian legal instruments varies between 50 and 200 m, regardless of the number of boats near these animals. In other countries, such as New Zealand and Portugal, the distance between boats and cetaceans may vary according to the number of boats (AÇORES, 2003; NEW ZEALAND, 1992). When three or more boats are present simultaneously in New Zealand, they must keep at least 300 m away from any whale species (NEW ZEALAND, 1992). In the Azores, Portugal, each boat can remain near a cetacean for up to 15 min and maintain a distance of at least 50 m from any cetacean species. When there are three or more boats, a distance of 300 m must be maintained for small cetacean species and 500 m for whales (AÇORES, 2003). Although these legal instruments are somewhat similar, such as the distance between boats and cetaceans, there are also some differences, such as the maximum time boats can remain in the presence of cetaceans. However, in some Brazilian legal instruments, this variable is not even mentioned (IBAMA, 1995; MANGARATIBA-RJ, 2012).

To control whale-watching, measures were proposed to protect whales and dolphins based on the mentioned legal instruments (Figure 3). To interact with species of the suborder Mysticeti, a limit of ≥100 m is suggested between boats and whales, based on Ibama Ordinance nº 117, of December 26, 1996 (IBAMA, 1996) and the environmental protection and biodiversity conservation regulation of Australia (AUSTRALIA, 2000). Although swimming with whales is prohibited in several countries, in Brazil, Ordinance nº 117, of December 26, 1996, forbids this practice only at 50 m or less between the swimmers and any whale species (IBAMA, 1996). However, this type of interaction is risky and may result in negative impacts (FIORI *et al.*, 2019). Therefore, based on the Australian regulation, swimmers and divers are suggested to maintain a distance ≥100 m from whales. For species of the suborder Odontoceti, a distance of ≥50 m is suggested between boats and dolphins, given the risk of running them over (TOLEDO *et al.*, 2017). This distance has also been adopted in the legal instruments of Australia and the Azores (AÇORES, 2003; AUSTRALIA, 2000).

As a protection measure, it is suggested that aircraft should not approach to ≤150 m above sea level and horizontally from a point directly above any cetacean species, based on the New Zealand guidelines (NEW ZEALAND, 1992). Interactions should not exceed 30 min (IBAMA, 1996), given that prolonged cetacean exposure to boats may reduce the resting time of these animals (FUMAGALLI *et al.*, 2018). Although there is no consensus between legal instruments, a speed less than or equal to 4 knots is suggested since studies show that boats travelling at this speed may cause fewer adverse responses in key species (SPROGIS; VIDESEN; MADSEN, 2020). Feeding cetaceans should be prohibited to avoid compromising the health of these animals (VIDAL *et al.*, 2017).

Females with calves may be the most frequent targets of whale-watching (BEJDER *et al.*, 2019). This is because changes in swimming and diving patterns are associated with evasive strategies. In addition, energy expenditure in response to disturbance may affect offspring development and survival (BEJDER *et al.*, 2019). As such, females with calves need more restrictive measures to guarantee their protection (FIORI *et al.*, 2019), and it is suggested that boats maintain a distance ≥200 m from females with calves (NEW ZEALAND, 1992) and that observation time does not exceed 15 min.

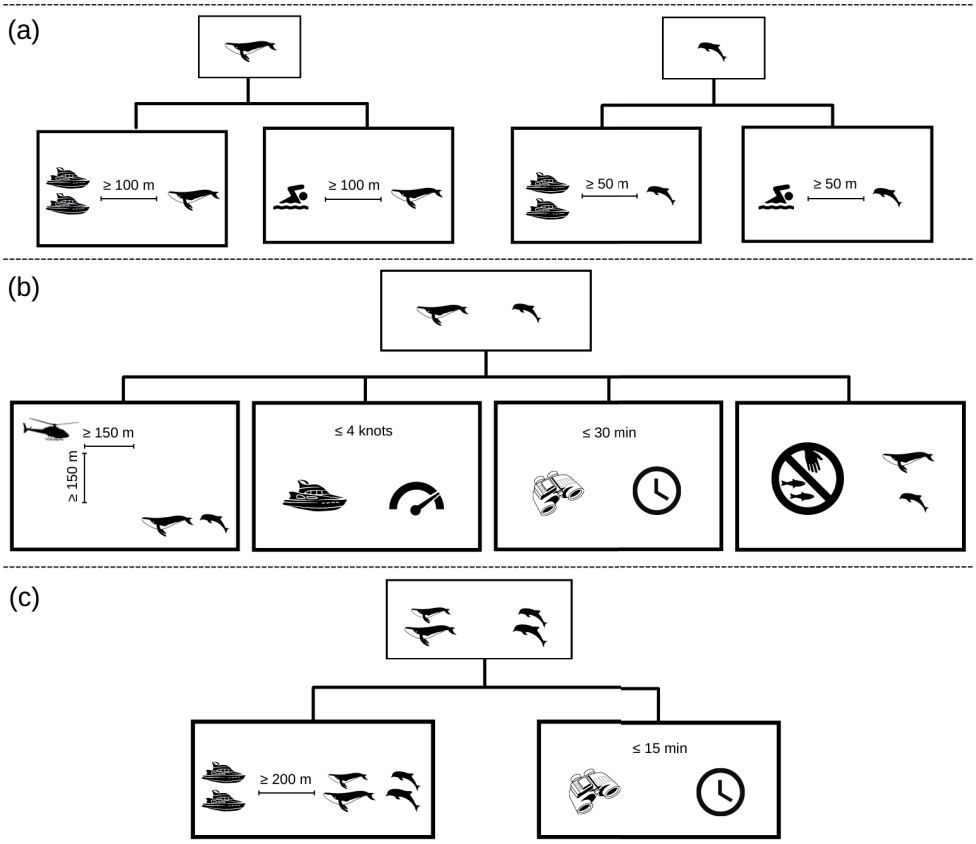

Figure 3 | Proposed measures to be included in standardized legal instruments to protect cetaceans: (a) Specific: the distance between boats and cetaceans and swimmers and cetaceans, (b) Common: the distance between aircraft and cetaceans, boat speed, observation time and not feeding the animals, (c) Specific for females with calves: distance of boats and observation time.

Source: Prepared by the authors, 2022.

5 FINAL CONSIDERATIONS

In this study, we sought to identify the whale-watching reference areas in Brazil and their key species. A total of 29 reference areas were found in 11 states, and seven key whale-watching species: humpback whale, southern right whale, Guiana dolphin, spinner dolphin, bottlenose dolphin, Amazon river dolphin, and tucuxi dolphin. In addition, we investigated how whale-watching is conducted in Brazil. Unfortunately, this activity does not have a single standardized legal instrument, although at the federal level, Ibama Ordinance nº 117, of December 26, 1996, aims at preventing and curbing intentional molestation of cetaceans found in Brazilian jurisdictional waters.

Given that boats have potential negative impacts on cetaceans, a standardized national legal enforcement instrument should regulate the following for all cetaceans subject to whale-watching: distance between boats and cetaceans; distance between swimmers and cetaceans; distance between aircraft and cetaceans; the maximum number of boats operating simultaneously; boat speed; observation time; and no animal feeding, in addition to a specific regulation for females with calves watching. This enforcement instrument should consider studies on cetacean behavioural changes resulting from interaction with boats. Ibama Ordinance nº 117, of December 26, 1996, stipulates that protected areas establish these limits. However, some whale-watching reference areas are not legally protected. To promote comprehensive cetacean conservation and sustainable ecotourism, it is suggested that legal

enforcement instruments be the basis for the continuous training of social actors and research on the environmental indicators for whale-watching monitoring.

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Turismo de observação de cetáceos no Brasil

Whale-watching in Brazil

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ARTICLE – VARIA

RESUMO

Este estudo pretendeu investigar o turismo de observação de cetáceos no Brasil, a partir de um levantamento de suas áreas de ocorrência, espécies-chave, e normas e regulamentos vigentes. A metodologia inclui uma pesquisa bibliográfica sobre áreas de ocorrência de cetáceos no Brasil, turismo de observação, instrumentos legais e códigos de conduta para o ordenamento dessa atividade. Foi realizada uma busca por áreas de referência do turismo de observação de cetáceos em homepage de agências e operadoras de turismo. A coleta de dados se deu por meio de contato telefônico, e-mail e redes sociais das agências e operadoras de turismo. Neste estudo, foram identificadas sete espécies de cetáceos-chave do turismo de observação, 29 áreas de referência, com 79% dessas áreas inseridas em Unidades de Conservação. Os resultados deste estudo poderão subsidiar ações de monitoramento e fiscalização do turismo de observação de cetáceos, visando seu ordenamento e a proteção desses animais.

Palavras-chave: Baleia. Ecoturismo. Golfinho. Mamíferos aquáticos. Unidades de conservação.

ABSTRACT

This study aimed to investigate whale-watching in Brazil by surveying its areas of occurrence, key species, and current guidelines and regulations. The methodology includes a bibliographic search of cetacean occurrence and whale-watching areas in Brazil, legal instruments, and codes of conduct regulating

this activity. A search for whale-watching areas was carried out on the homepage of tourist agencies and operators. In addition, data were collected via telephone, email, and social media of the tourist agencies and operators. In this study, we identified seven cetacean species and 29 whale-watching areas, 79% of which are protected areas. The results of this study may help monitor and enforcement measures for whale-watching aimed at protecting these animals.

Keywords: Whale. Ecotourism. Dolphin. Aquatic mammals. Protected areas.

1 INTRODUÇÃO

No Brasil, o turismo de observação de cetáceos (TOC) provavelmente se iniciou na década de 1980, em Fernando de Noronha (PE) com o golfinho-rotador, *Stenella longirostris*, e no estado do Amazonas (AM) com o boto-vermelho, *Inia geoffrensis* (VIDAL *et al.*, 2017). Atualmente, outras espécies de cetáceos são chave do TOC no Brasil, como o boto-cinza, *Sotalia guianensis* (LUNARDI *et al.*, 2017), a baleia-jubarte, *Megaptera novaeangliae* (FERNANDES; ROSSI-SANTOS, 2018) e a baleia-franca-do-sul, *Eubalaena australis* (GROCH, 2018). Essa atividade pode gerar benefícios econômicos, por meio da geração de emprego e renda para a população local (LUNARDI *et al.*, 2017) e benefícios ambientais e educacionais, por meio da proteção dos recursos naturais e sensibilização dos turistas (GARCÍA-CEGARRA; PACHECO, 2017; TISCHER *et al.*, 2018).

Embora existam vários benefícios associados à prática do TOC, nem sempre a conservação da biodiversidade e a sustentabilidade socioeconômica são alcançadas. Quando realizado a partir de barcos motorizados, o TOC tem sido associado, com frequência, a efeitos negativos (MACEDO *et al.*, 2020). De acordo com a Lista Vermelha de Espécies Ameaçadas da *International Union for Conservation of Nature* (IUCN), em nível global, cinco espécies e 19 subespécies de cetáceos estão criticamente ameaçadas de extinção, enquanto 12 espécies e 12 subespécies estão ameaçadas de extinção (IUCN, 2022). Destas, quatro espécies são chave do TOC no Brasil e também se encontram ameaçadas de extinção em território nacional, como a baleia-franca-do-sul, boto-vermelho, tucuxi (*Sotalia fluviatilis*) e boto-cinza (MMA, 2022).

Para promover o ordenamento do TOC, alguns países contam com legislação específica. Por exemplo, na Austrália, a atividade é regulamentada desde 2000, por meio da Lei nº 181/2000, que dispõe sobre regulamentos de proteção ambiental e conservação da biodiversidade, com um capítulo dedicado à interação e observação de cetáceos (AUSTRALIA, 2000).

Na Nova Zelândia, o Regulamento de Proteção de Mamíferos Marinhos (MMPR), promulgado em 1988 e atualizado em 1992 e 2008, estabelece as condições adequadas para a observação de cetáceos, diretrizes de abordagem para embarcações e outras interações com mamíferos marinhos (NEW ZEALAND, 1992).

Nos Açores, Portugal, o TOC é regulamentado por meio do Decreto legislativo regional nº 10, de 22 de março de 2003/A, e tem por objetivo proteger e conservar os cetáceos e fomentar o desenvolvimento e a gestão turística (AÇORES, 2003).

Em Chubut, na Argentina, o TOC é regulamentado pela Lei nº 5.714, de 21 de dezembro de 2007, que proíbe abordagem e perseguição à baleia-franca-do-sul, e pelo Decreto nº 167, de 29 de fevereiro de 2008, que estabelece os aspectos técnicos permitidos e proibidos para o serviço de transporte (CHUBUT, 2008).

No Brasil, a Lei nº 7.643, de 18 de dezembro de 1987, proíbe a pesca de cetáceos em águas jurisdicionais brasileiras (BRASIL, 1987), enquanto a Portaria Ibama nº 117, de 26 de dezembro de 1996, alterada pela Portaria nº 24, de 08 de fevereiro de 2002, proíbe a ação de molestamento de cetáceos e estabelece limites para as embarcações que operem em águas jurisdicionais brasileiras (IBAMA, 2002).

Apesar de o TOC ser instrumento de promoção de conservação ambiental e uma importante fonte de emprego e renda, ainda não há estudos dedicados a descrever como essa atividade ocorre nas principais áreas de concentração de cetáceos no Brasil. Este estudo pretendeu responder a duas questões: (i) Quais são as áreas de referência do TOC no Brasil e suas principais espécies-chave? (ii) Como o TOC é conduzido no Brasil? Os resultados apresentados neste estudo, como distribuição das áreas de referência, espécies-chave do turismo de observação de cetáceos no Brasil e variáveis a serem consideradas em um instrumento de ordenamento legal unificado, poderão subsidiar um plano nacional de ordenamento do TOC, que vise promover, de forma integrada, a conservação de cetáceos e a sustentabilidade do ecoturismo.

2 METODOLOGIA

O Brasil apresenta um dos litorais mais extensos da América Latina, com mais de 7.400 km de extensão, e águas jurisdicionais marítimas que, somando ao mar territorial, zona contígua e Zona Econômica Exclusiva, excedem 3,4 milhões de km² (NOTHEN, 2015). Além disso, o Brasil possui um conjunto de ilhas oceânicas e fluviais, que inclui os complexos insulares (IBGE, 2011).

Desde 2008, por meio do Decreto nº 6.698, de 17 de dezembro de 2008, as águas jurisdicionais marinhas brasileiras foram declaradas Santuário de Baleias e Golfinhos do Brasil, permitindo a pesquisa científica e o aproveitamento turístico ordenado (BRASIL, 2008). Ao longo de uma zona costeira de mais de 7.400 km (NOTHEN, 2015), zona marinha e águas interiores, já foram registradas, até o momento, 59 espécies de cetáceos no Brasil (ICMBIO, 2019).

Para a identificação e descrição das principais áreas de TOC no Brasil, foi realizada uma ampla pesquisa bibliográfica (SOUSA *et al.*, 2021) sobre essas áreas e sobre o TOC, e uma análise documental de instrumentos legais e códigos de conduta para o seu ordenamento, de julho de 2020 a junho de 2022. Foram incluídos artigos científicos e capítulos de livro, publicados nos últimos 30 anos, em português, inglês e espanhol, em uma busca nas bases de dados do Periódicos Capes (www.periodicos.capes.gov.br), Scielo (www.scielo.br), ScienceDirect (www.sciencedirect.com) e Google Acadêmico (scholar.google.com.br), além de instrumentos legais divulgados em plataformas governamentais. Os dados obtidos neste estudo foram analisados de acordo com a abordagem de análise documental (CECHINEL *et al.*, 2016), que se iniciou pela avaliação e exame preliminar de cada instrumento legal, sob o olhar de elementos como esfera administrativa das UC, espécie-chave e variáveis do ordenamento turístico de observação de cetáceos.

Adicionalmente, foi realizada uma busca de informações sobre o TOC em *homepage* de agências e operadoras de turismo e via contato telefônico, e-mail e redes sociais. Considerou-se turismo de observação de cetáceos a atividade comercial, divulgada em plataforma on-line, de oferta de serviço para turistas observarem uma ou mais espécies de cetáceos, em seu ambiente natural. Áreas de referência do turismo de observação de cetáceos foram consideradas aquelas áreas cujas informações sobre comercialização de passeios turísticos estão disponíveis em plataformas *on-line* de agências de turismo ou publicadas em artigos científicos. Para a descrição do TOC no Brasil, foram registrados: (i) área, município e estado de ocorrência da atividade; (ii) espécies-chave do TOC; (iii) presença de Unidade de Conservação (UC) na área de ocorrência da atividade; (iv) plataforma de observação; (v) instrumento legal vigente; (vi) duração do passeio; (vii) custo do passeio (R$) e (viii) existência de palestras ou outro tipo de comunicação ambiental, antes ou durante o passeio. Em caso de instrumento legal vigente na área, voltado ao ordenamento do TOC, também foram registradas as medidas restritivas para o seu ordenamento.

Dados referentes à descrição do TOC no Brasil foram agrupados e analisados de forma comparativa. É importante destacar que, embora existam, no Brasil, diversas áreas de concentração de cetáceos, algumas não dispõem de operadoras comerciais locais ou informações sobre suas atividades não estão

disponíveis *on-line* e, portanto, não foram incluídas neste estudo. É o caso, por exemplo, do turismo de observação de baleias-jubarte no Arquipélago de Fernando de Noronha (PE) e no litoral sul do Rio Grande do Norte (RN).

3 RESULTADOS

No Brasil, o TOC tem como foco duas espécies de baleias e cinco espécies de golfinhos, e está presente em pelo menos 26 municípios, distribuídos em 11 estados e quatro regiões brasileiras (Tabela 1). A baleia-jubarte, por exemplo, pode ser observada na zona litorânea de Salvador, Mata de São João, Porto Seguro, Ilhéus, Itacaré e Caravelas ou ainda no Arquipélago dos Abrolhos (BA), podendo também ser observada no litoral sul do Rio Grande do Norte (RN), na zona litorânea de Vitória (ES) e no Arquipélago de Alcatrazes (SP). Já a baleia-franca-do-sul pode ser observada na zona litorânea de Garopaba, Imbituba e Laguna (SC). Entre as espécies de golfinhos, há o boto-cinza, que pode ser observado na zona litorânea de Fortaleza (CE) e de Tibau do Sul (Figura 1), Nísia Floresta e Baía Formosa (RN), ou ainda na zona litorânea dos municípios de Ilhéus, Caravelas e Jandaíra (BA). O turismo de observação de botos-cinza também ocorre na zona litorânea de Mangaratiba, Guapimirim e Paraty (RJ), e em Cananéia (SP), Paranaguá e Guaraqueçaba (PR), ou ainda na zona litorânea de Governador Celso Ramos e São Francisco do Sul (SC).

O golfinho-rotador é frequentemente observado no Arquipélago de Fernando de Noronha (PE), enquanto o boto-da-tainha, *Tursiops truncatus*, pode ser observado em Laguna (SC). O boto-vermelho é chave do TOC em Manaus e Novo Airão (AM), e em Santarém (PA), enquanto o tucuxi pode ser observado em Santarém (PA) e na Reserva de Desenvolvimento Sustentável Mamirauá, Tefé (AM) (Figura 2).

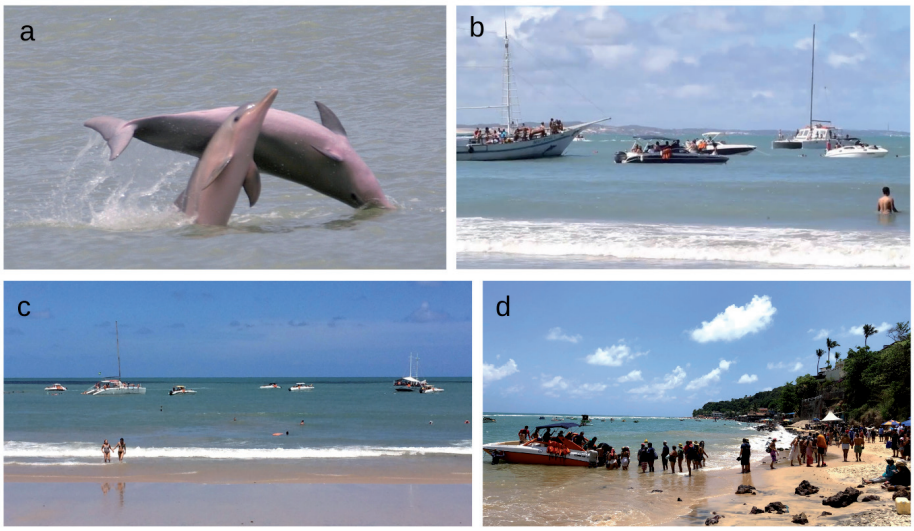

Figura 1 | Turismo de observação de botos-cinza, Sotalia guianensis (a), na Reserva de Fauna Costeira de Tibau do Sul (Refauts) (RN), Brasil. Destaque para cinco (b) e sete (c) embarcações na Zona de Uso Restrito. Local de embarque de turistas (d).

Fonte: LUNARDI, D. G.; LUNARDI, V. O., 2021.

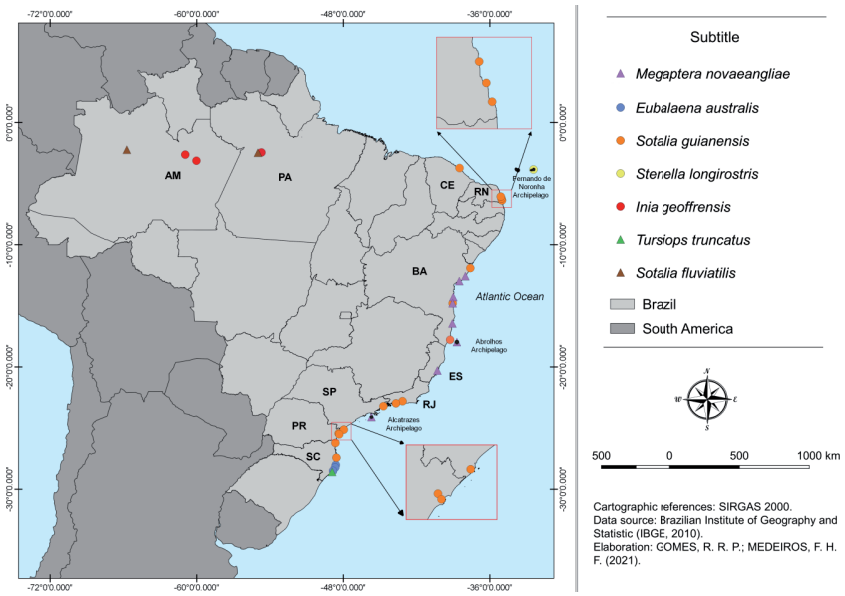

Figure 2 | Áreas de referência das espécies-chave do turismo de observação de cetáceos no Brasil.

Fonte: GOMES e MEDEIROS, 2021.

Das 29 áreas de referência, que contam com o TOC, 23 (ou 79%) delas inclui, em seu território, área legalmente protegida, na forma de UC, sendo dez áreas de domínio federal, sete áreas de domínio estadual e outras quatro áreas de domínio municipal (Tabelas 1 e 2). Vale salientar que a APA de Guaraqueçaba abrange dois municípios do estado do Paraná – Paranaguá e Guaraqueçaba. As UC, indicadas neste estudo, incluem Unidades de Uso Sustentável (n=17) e de Proteção Integral (n=4), conforme o Sistema de Unidades de Conservação da Natureza (BRASIL, 2000a), designadas como Área de Proteção Ambiental (n=13), Parque Nacional (n=3), Reserva Extrativista (n=2), Reserva de Fauna (n=1), Reserva de Desenvolvimento Sustentável (n=1) e Refúgio de Vida Silvestre (n=1), criadas por meio de Lei ou Decreto, a partir de 1981.

Tabela 1 | Áreas de referência do turismo de observação de cetáceos no Brasil. Unidade de Conservação (UC). Parque Nacional Marinho (Parnamar). Área de Proteção Ambiental (APA). Reserva Extrativista (Resex). Refúgio de Vida Silvestre (RVS). DM: Decreto Municipal. DE: Decreto Estadual. DF: Decreto Federal.

Espécie	*Área*	*Estado*	*Unidade de Conservação?*	*Instrumento legal de criação da UC*
Baleia-jubarte	Salvador	BA	não	—
	Abrolhos	BA	Parnamar Abrolhos	DF nº 88.218/1983
	Mata de São João	BA	APA Litoral Norte do Estado da Bahia	DE nº 1.046/1992
	Porto Seguro	BA	Resex Marinha do Corumbau	DF s/n 2000
	Ilhéus	BA	APA Lagoa Encantada e Rio Almada	DE nº 2.217/1993 alterado pelo DE nº 8.650/2003
	Itacaré	BA	não	—
	Vitória	ES	APA Baía das Tartarugas	DM nº 17.342/2018
	Arquipélago de Alcatrazes	SP	RVS Arquipélago de Alcatrazes	DF s/n 2016
Baleia-franca-do-sul	Imbituba	SC	APA da Baleia-franca	DF s/n 2000

Fonte: Dados da Pesquisa, 2022.

Tabela 2 | Áreas de referência do turismo de observação de cetáceos no Brasil. Unidade de Conservação (UC). Reserva de Fauna (Refau). Área de Proteção Ambiental (APA). Parque Nacional (Parna). Reserva Extrativista (Resex). Reserva de Desenvolvimento Sustentável (RDS). DM: Decreto Municipal. DE: Decreto Estadual. DF: Decreto Federal. LM: Lei Municipal.

Espécie	Área	*Estado*	*Unidade de Conservação?*	*Instrumento legal de criação da UC*
Boto-cinza	Fortaleza	CE	não	—
	Tibau do Sul	RN	Refau Tibau do Sul	DM nº 14/2006 alterado pela Lei nº 616/2018
	Nísia Floresta	RN	APA Bonfim-Guaraíra	DE nº 14.369/1999
	Baía Formosa	RN	não	—
	Ilhéus	BA	APA Lagoa Encantada e Rio Almada	DE nº 2.217/1993 alterado pelo DE nº 8.650/2003
	Caravelas	BA	APA Ponta da Baleia	DE n° 2.218/1993
	Jandaíra	BA	APA de Mangue Seco	DE nº 605/1991
	Mangaratiba	RJ	APA Marinha Boto-cinza	LM nº 940/ 2014
	Guapimirim	RJ	APA Guapi-Mirim	DF nº 90.225/1984
	Paraty	RJ	APA Baía de Paraty	LM nº 685/1984
	Cananéia	SP	APA de Cananéia-Iguape-Peruíbe	DF nº 90.347/1984
	Paranaguá	PR	APA de Guaraqueçaba	DF nº 90.883/1985
	Guaraqueçaba	PR	APA de Guaraqueçaba	DF nº 90.883/1985
	São Francisco do Sul	SC	não	—
	Governador Celso Ramos	SC	APA do Anhatomirim	DF nº 528/1992
Golfinho-rotador	Fernando de Noronha	PE	Parnamar de Fernando de Noronha	DF nº 96.693/1988
Boto-da-tainha	Laguna	SC	APA da Baleia-franca	DF s/n 2000
Boto-vermelho	Novo Airão	AM	Parna de Anavilhanas	DF nº 86.061/1981 alterado pela Lei nº 11.799/2008
	Manaus	AM	Não	—
	Santarém	PA	Resex Tapajós-Arapiuns	DF s/n 1998
Tucuxi	Tefé	AM	RDS Mamirauá	DE nº 12.836/1990 alterado pela Lei nº 2.411/1996
	Santarém	PA	Resex Tapajós-Arapiuns	DF s/n 1998

Fonte: Dados da Pesquisa, 2022.

A maioria dos passeios para observação de cetáceos no Brasil ocorre a partir de embarcações como escunas, catamarãs e lanchas, mas a atividade de observação turística também pode ocorrer a partir da faixa de praia, mirantes e plataformas flutuantes, a exemplo da observação do boto-vermelho, no flutuante dos botos, em Novo Airão. O custo do *ticket* para observação de cetáceo pode variar de R$ 30,00 a R$ 458,00, dependendo da localidade, duração da atividade e infraestrutura oferecida ao turista. É importante destacar que esses valores foram consultados, junto às operadoras de turismo, de janeiro a junho de 2022 (Tabela 3). O turismo de observação de baleias-jubarte ocorre de maio a

outubro, enquanto a temporada para observação de baleia-franca-do-sul ocorre de julho a novembro, já que ambas as espécies são migratórias. Para a observação de golfinhos, os passeios ocorrem diária ou semanalmente, durante todo o ano (Tabela 3).

Tabela 3 | Descrição do turismo de observação de cetáceos no Brasil. *O passeio não é vendido separadamente e inclui hospedagem e alimentação.

Espécie-chave	*Área*	*Plataforma*	*Custo (R$)*	*Duração (min.)*	*Temporada*
Baleia-jubarte	Salvador	barco	300,00	240	jul. a out.
	Abrolhos	barco	458,00	300	
	Mata de São João	barco	280,00	300	
	Porto Seguro	barco	250,00	240	
	Ilhéus	barco	250,00	240	
	Itacaré	barco	250,00	240	
	Vitória	barco	360,00	480	
	Arquipélago de Alcatrazes	barco	450,00	540	mai. a ago.
Baleia-franca-do-sul	Imbituba	ponto de observação	200,00	240	jul. a nov.
Boto-cinza	Fortaleza	barco	40,00	120	jan. a dez.
	Tibau do Sul	barco	60,00	50	
	Nísia Floresta	ponto de observação	50,00	120	
	Baía Formosa	barco	40,00	60	
	Ilhéus	barco	250,00	300	
	Caravelas	barco	120,00	180	
	Jandaíra	barco	150,00	120	nov. a mai.
	Mangaratiba	barco	150,00	90	jan. a dez.
	Guapimirim	barco	150,00	150	
	Paraty	barco	100,00	300	
	Cananéia	barco	50,00	360	
	Paranaguá	barco	100,00	240	
	Guaraqueçaba	barco	100,00	180	
	São Francisco do Sul	barco	80,00	240	
	Governador Celso Ramos	barco	125,00	300	
Golfinho-rotador	Fernando de Noronha	barco	450,00	300	
		ponto de observação	147,00	120	
Boto-da-tainha	Laguna	ponto de observação	300,00	180	
Boto-vermelho	Novo Airão	plataforma flutuante	30,00	60	
		barco	120,00	180	
	Manaus	plataforma flutuante	160,00	360	
	Santarém	barco	120,00	60	
Tucuxi	Tefé	barco	*	240	
	Santarém	barco	120,00	60	

Fonte: Dados da Pesquisa, 2022.

Das 29 áreas de referência, em pelo menos 17, o TOC é realizado em parceria com projetos ou instituições de pesquisa, o que favorece a apresentação de palestras, antes ou durante a atividade de observação de cetáceos. Destas, 16 promovem palestras associadas aos passeios para observação de cetáceos, mas apenas três operadoras de turismo das áreas de referência Abrolhos, Ilhéus e Jandaíra disponibilizaram, em suas *homepages,* normas de conduta de observação de cetáceos, que visam garantir o bem-estar desses animais.

Das 29 áreas de referência, oito contam com instrumentos legais para o ordenamento do TOC (Tabela 4). Esses instrumentos legais restringem a velocidade, o tempo de permanência, o tipo de manobra e o número de barcos simultâneos na área de concentração de cetáceos. Destaca-se que a Portaria ICMBio/MMA nº 1.112, de 17 de dezembro de 2018, é destinada ao ordenamento turístico na APA da Baleia-franca, que possui sede em Imbituba, mas as atividades turísticas de observação da baleia-franca-do-sul também ocorrem em Laguna e Garopaba, que integram a rota migratória dessa espécie. Vale salientar que o turismo de observação de baleia-franca-do-sul está suspenso desde 2013, por meio de uma determinação da Vara da Justiça Federal de Laguna (SC). Desde então, a observação dessa espécie tem ocorrido a partir da costa litorânea (TRF4, 2013).

Tabela 4 | Instrumentos legais que tratam do ordenamento turístico de observação de cetáceos no Brasil. *Distância entre embarcação e cetáceo.

Espécie Instrumento legal	*Distância**	*Velocidade do barco*	*Duração da interação*	*Manobra proibida*	*Nº máx. de barcos*
Mysticeti, cachalote e orca Portaria nº 24/2002 (IBAMA, 2002)	100 m	—	30 min.	perseguição	02
baleia-franca-do-sul Portaria nº 1.112/2018 (ICMBIO, 2018)	≥120 m	≤5 nós	≤30 min.	perseguição ou interrupção do deslocamento	02
boto-cinza Lei nº 349/2007 (TIBAU DO SUL-RN, 2007)	≥50 m	≤4 nós	≤20 min.	aproximação ou perseguição	01
boto-cinza Lei n° 832/2012 (MANGARATIBA-RJ, 2012)	—	—	—	—	02
boto-cinza Lei nº 2.129/2011 (CANANÉIA-SP, 2011)	≥50 m	baixa velocidade a ≤500 m de prox.	≤30 min.	mudança de direção, aproximação ou perseguição	02
boto-cinza Lei nº 3833/2019 (PARANAGUÁ-PR, 2019)	≥50 m	baixa velocidade a ≤500 m de prox.	≤30 min.	mudança de direção, aproximação ou perseguição	02
boto-cinza Portaria nº 5-N/1998 (IBAMA, 1998)	—	≤2 nós	≤15 min.	perseguição e movimentos circulares	02
golfinho-rotador Portaria nº 5-N/1995 (IBAMA, 1995)	≥200 m	≤5 nós	—	perseguição	02
boto-vermelho Resolução nº 28/2018 (CEMAAM, 2018)	≥100 m	≤5 nós	≤15 min.	alteração ou interrupção do deslocamento	—

Fonte: Dados da Pesquisa, 2022.

4 DISCUSSÃO

Das 59 espécies de cetáceos que ocorrem em águas brasileiras (ICMBIO, 2019), pelo menos sete espécies são chave do TOC, com registro em água fluvial e ampla distribuição litorânea, que se estende de Santa Catarina até o Ceará. No Brasil essa atividade ocorre, predominantemente, em UC. Das 29 áreas de referência do TOC, 23 áreas incluem UC, sendo a maior parte delas de uso sustentável. Entre as UC de uso sustentável, com ocorrência do TOC, a categoria APA é a mais comum. A APA tem como objetivos básicos proteger a diversidade biológica, disciplinar o processo de ocupação e assegurar a sustentabilidade do uso dos recursos naturais (BRASIL, 2000a). Levando em consideração o atual *status* de conservação de algumas espécies de cetáceos, as APA podem não ser a categoria de UC mais adequada à proteção desses animais, uma vez que permite o uso direto de recursos naturais. Espécies ameaçadas de extinção, como a baleia-franca-do-sul ou o boto-cinza (MMA, 2022), deveriam ser protegidas por UC mais restritivas, quanto à ocupação humana e as atividades antrópicas permitidas, a exemplo de Reservas de Fauna (Refau) ou Reservas de Desenvolvimento Sustentável (RDS), que permitem apenas o manejo sustentável dos recursos naturais (BRASIL, 2000a).

Atualmente, a baleia-franca-do-sul conta apenas com a APA da Baleia-franca, SC, para proteção de seu *habitat* (BRASIL, 2000b), enquanto o boto-cinza tem parte de sua área de distribuição geográfica protegida pela APA Marinha Boto-cinza (RJ) (MANGARATIBA-RJ, 2014), APA de Cananéia-Iguape-Peruíbe (SP) (BRASIL, 1984) e pela APA Bonfim-Guaraíra (RN) (RIO GRANDE DO NORTE, 1999).

Um número expressivo de áreas de referências do TOC, em território legalmente protegido, está situado na Bahia, provavelmente por sua extensa zona costeira. No entanto, Santa Catarina é o estado com maior número de espécies-chave do TOC, que inclui baleia-franca-do-sul (RENAULT-BRAGA *et al.*, 2018), boto-da-tainha (AGRELO *et al.*, 2019) e boto-cinza (MACEDO *et al.*, 2020). O boto-cinza é a espécie-chave com maior número de áreas de referência do TOC no Brasil, ocorrendo em 48% das áreas registradas, devido a sua ampla distribuição geográfica e hábito costeiro. Sua área de ocorrência compreende desde a Costa Atlântica da América do Sul e América Central até as Honduras (SECCHI; SANTOS; REEVES, 2018).

A maioria das UC no Brasil, que inclui o TOC em seu território, é de domínio federal, enquanto apenas quatro UC são de domínio municipal: Refau Costeira de Tibau do Sul, APA Baía das Tartarugas, APA Boto-cinza e APA Baía de Paraty. Diferente das UC municipais, a gestão ambiental em áreas de domínio federal conta com uma maior estrutura organizacional especializada. O Parna Marinho de Fernando de Noronha, por exemplo, dispõe de plataforma com acesso a todas as suas informações (www.parnanoronha.com.br), que inclui desde normas de acesso e atrativos turísticos até instrumentos legais, como a Portaria que instituiu o Núcleo de Gestão Integrada de Fernando de Noronha.

A gestão integrada do ICMBio Noronha busca alcançar, de forma prioritária, maior efetividade na conservação da biodiversidade e na realização dos objetivos de criação das UC, atuando com um único conselho consultivo (ICMBIO, 2017). O Parna Marinho de Fernando de Noronha ainda conta com uma concessionária, à qual compete prestar serviços de apoio à visitação pública e a cobrança pelo valor do ingresso de visitação.

Em um cenário diferente do relatado para o Parna Marinho de Fernando de Noronha, a Refau Costeira de Tibau do Sul (Refauts), de gestão municipal, não dispõe de infraestrutura para a gestão sustentável dos recursos naturais ou recepção dos visitantes, nem tampouco dispõe de uma plataforma *on-line,* que permita o acesso a informações sobre a Refauts ou sobre o turismo de observação de botos-cinza. Nesse sentido, uma parte significativa das pessoas que visitam a Refauts e realizam o passeio para observação de botos-cinza não sabe que essa espécie está ameaçada de extinção ou que esse território se trata de uma Refau (SILVA *et al.*, 2021). Após mais de uma década de sua criação, a gestão da Refauts ocorre de maneira deficiente, tendo em vista a ausência de um órgão gestor especializado.

Em junho de 2021, o Ministério Público Federal, por intermédio do Procurador da República, emitiu Recomendação nº 06/2021, referente às atividades na Refauts, para: criação de um grupo interinstitucional para traçar estratégias de paralisação da mortandade de botos-cinza em Tibau do Sul (RN); elaboração de um plano de fiscalização da atividade pesqueira e do TOC; estudo técnico para o ordenamento da atividade pesqueira e do TOC; e realização de campanha de divulgação e sensibilização ambiental e de curso de formação continuada em conservação ambiental para atores sociais (MPF, 2021).

A criação de UC, que incluem em seu território áreas de concentração de cetáceos no Brasil, iniciou-se em 1981, com a criação da Esec de Anavilhanas, que, em 2008, passou a ser o Parna de Anavilhanas, uma importante área de proteção do boto-vermelho (BRASIL, 2008). Nas décadas de 1980 e 1990, houve a criação da maioria das UC, que incluem, em seu território, áreas de referência do TOC no Brasil, contrastando com a última década, na qual apenas três novas UC foram instituídas no país. Nesse sentido, a última UC foi instituída em 2018, com a criação da APA Baía das Tartarugas, de âmbito municipal, que protege uma pequena parte da área de distribuição geográfica das baleias-jubarte (VITÓRIA-ES, 2018). Desde 2019, não tem havido qualquer avanço em instituir novas UC para proteção de cetáceos-chave do TOC no Brasil, embora a criação de novas UC seja urgente e necessária.

Pelo menos seis áreas de referência do TOC ainda estão sem proteção legal: Salvador e Itacaré (BA), para observação de baleia-jubarte; Fortaleza (CE); Baía Formosa (RN), e São Francisco do Sul (SC), para observação de boto-cinza e Manaus (AM), para observação do boto-vermelho. A ausência de proteção legal nessas áreas pode comprometer a conservação de cetáceos, especialmente aqueles ameaçados de extinção, uma vez que estarão mais expostos a efeitos negativos, provocados pelo TOC (KASSAMALI-FOX *et al.*, 2020; MAREGA-IMAMURA *et al.*, 2018). Visando a proteção desses animais e a sustentabilidade do TOC, em longo prazo, é necessário que sejam instituídas novas UC, com foco no ordenamento das atividades turísticas e na conservação das espécies ameaçadas de extinção.

A observação de cetáceos é considerada uma fonte importante de recurso financeiro, oferecendo maior renda do que outras atividades turísticas (SOTO-CORTÉS; ACOSTA; MAYA, 2021). Os benefícios econômicos do TOC incluem geração de emprego e renda anual de milhões de dólares para esse setor (GUIDINO *et al.*, 2020). No Brasil, o custo desses passeios varia em função de sua duração, infraestrutura disponível e outros atrativos oferecidos aos turistas, mas, a princípio, os preços parecem ser similares aos aplicados em países vizinhos. Na Colômbia, passeios com duração de 12 h para observar baleias-jubarte, realizados no Parque Nacional Natural Uramba Bahía Málaga, custavam cerca de R$ 600,00 (grancolombiatours.com) em junho de 2022. No Brasil, áreas de referência como os Arquipélagos dos Abrolhos, de Alcatrazes e de Fernando de Noronha têm um custo elevado, provavelmente pelo fato de serem arquipélagos de difícil acesso e apresentarem elevada riqueza de espécies e alto grau de conservação de suas áreas naturais (DUTRA *et al.*, 2006).

Embora a maior parte da observação de cetáceos ocorra a partir de barcos, há áreas de referência nas quais a observação é possível também a partir da costa, na faixa de praia ou em um mirante – uma alternativa viável e ambientalmente mais adequada, uma vez que contribui para a redução dos impactos ambientais negativos, causados por barcos motorizados (TISCHER *et al.*, 2020). Até 2013, o turismo de observação de baleia-franca-do-sul se dava principalmente a partir de barcos motorizados, mas foi suspenso (TRF4, 2013) devido aos impactos negativos que podem causar a essa espécie em perigo de extinção (CHALCOBSKY; CRESPO; COSCARELLA, 2020).

Atualmente, a observação de baleia-franca-do-sul tem ocorrido na costa litorânea de Imbituba, Laguna e Garopaba (SC). Apesar das plataformas fixas contribuírem para a redução dos impactos negativos, elas também podem ser usadas de forma inadequada. Em Novo Airão (AM), botos-vermelho apresentaram alterações comportamentais devido ao fornecimento de alimentos (ALVES *et al.*, 2013) em plataformas fixas (CEMAAM, 2018). Em 2010, após iniciado o processo de Ordenamento do Turismo com Botos (GT Botos), uma série de iniciativas tem reduzido os efeitos negativos dessa prática, como a publicação da

Portaria nº 47, de 09 de abril de 2012, que estabelece normas para o ordenamento da visitação no Parna de Anavilhanas e que proíbe o turista de alimentar os botos (CEMAAM, 2018).

O TOC pode ser uma oportunidade para a sensibilização de turistas sobre a importância da conservação ambiental (GARCÍA-CEGARRA; PACHECO, 2017), além de promover benefícios econômicos, como geração de emprego e renda (LUNARDI *et al.*, 2017) e ambientais, como proteção da paisagem natural (BRUMATTI, 2013). Embora essa atividade represente uma oportunidade de ampliar estudos científicos, divulgar informações sobre os cetáceos e sensibilizar turistas (FERNANDES; ROSSI-SANTOS, 2018), pouco mais da metade das áreas de referência do TOC no Brasil conta com o apoio de projetos ou instituições de pesquisa, que contribuem com componentes educacionais, na forma de palestra, capacitação ou fornecimento de dados ecológicos e biológicos das espécies-chave. Áreas de referência, que contam com o apoio de institutos ou projetos de pesquisa, em geral, dispõem de normas de conduta para observação de cetáceos, consequentemente, a qualidade do turismo nessas áreas pode causar menos impactos negativos às espécies observadas (TISCHER *et al.*, 2017). A satisfação do turista tende a aumentar quando o passeio é acompanhado de componentes educacionais e os condutores de embarcação cumprem os regulamentos estabelecidos (SITAR *et al.*, 2017).

No Brasil, a Lei nº 7.643, de 18 de dezembro de 1987, foi o primeiro instrumento legal de proteção aos cetáceos, proibindo a pesca desses animais em águas jurisdicionais brasileiras (BRASIL, 1987). Já a Portaria Ibama nº 2.306, de 22 de novembro de 1990, posteriormente reformulada pela Portaria nº 117, de 26 de dezembro de 1996, estabelece como medida protetiva, a distância mínima de 100 m entre embarcação com motor ligado e qualquer espécie de baleia; altitude mínima de 100 m entre aeronaves e cetáceos; limite máximo de 30 min para observação de qualquer grupo de baleias; distância mínima de 50 m para mergulho ou natação nas proximidades de qualquer espécie de baleia; e normas para operação de embarcações de turismo em UC (IBAMA, 1990; IBAMA, 1996).

A Portaria nº 24, de 08 de fevereiro de 2002, estabeleceu que os barcos devem manter seus motores no ponto neutro ao observar baleias-jubarte, e desligados ou em neutro para outras espécies de cetáceos. Estabeleceu também o limite de duas embarcações que podem se aproximar de um indivíduo ou grupo de baleias simultaneamente (IBAMA, 2002).

No geral, a distância entre barcos e cetáceos, estabelecida nos instrumentos legais do Brasil, varia de 50 a 200 m, independentemente do número de barcos que estejam próximos a esses animais. Em outros países, como Nova Zelândia e Portugal, a distância entre barcos e cetáceos pode variar de acordo com o número de embarcações (AÇORES, 2003; NEW ZEALAND, 1992). Na Nova Zelândia, quando há três ou mais barcos, simultaneamente, deve-se manter uma distância de pelo menos 300 m entre barcos e qualquer espécie de baleia (NEW ZEALAND, 1992). Nos Açores, Portugal, cada embarcação pode permanecer próximo a um cetáceo por até 15 min, devendo manter uma distância de 50 m para qualquer espécie de cetáceo. Para aqueles casos em que haja três ou mais barcos, deve-se manter uma distância de 300 m para espécies de pequenos cetáceos e 500 m para espécies de baleias (AÇORES, 2003). Embora esses instrumentos legais tenham alguma similaridade, como a distância a ser mantida entre barcos e cetáceos, também há algumas diferenças, como o tempo máximo de permanência dos barcos na presença de cetáceos. Contudo, em alguns instrumentos legais do Brasil, essa variável não é nem mesmo mencionada (IBAMA, 1995; MANGARATIBA-RJ, 2012).

Para promover o ordenamento do TOC, foram propostas medidas que visam a proteção de baleias e golfinhos, com base nos instrumentos legais citados (Figura 3). Para a interação com espécies da subordem Mysticeti, sugere-se o limite de ≥100 m de distância entre barcos e baleias, com base na Portaria Ibama nº 117, de 26 de dezembro de 1996 (IBAMA, 1996) e no regulamento de proteção ambiental e conservação da biodiversidade da Austrália (AUSTRALIA, 2000). Apesar da natação com baleias ser proibida em vários países, no Brasil, a Portaria nº 117, de 26 de dezembro de 1996, proíbe tal prática apenas a uma distância inferior a 50 m entre nadadores e qualquer espécie de baleia (IBAMA, 1996). No entanto, esse tipo de interação é arriscado e pode resultar em impactos negativos (FIORI *et*

al., 2019). Com base no regulamento australiano, sugere-se que pessoas em atividade de natação e mergulho mantenham uma distância ≥100 m das baleias. Para espécies da subordem Odontoceti, é sugerida uma distância ≥50 m entre barcos e golfinhos, considerando o risco de atropelamento (TOLEDO *et al.*, 2017). Essa distância também tem sido adotada no instrumento legal vigente na Austrália e na região dos Açores (AÇORES, 2003; AUSTRALIA, 2000).

Como medida de proteção, sugere-se que aeronaves não devam se aproximar a ≤150 m acima do nível do mar e, horizontalmente, de um ponto direto acima de qualquer espécie de cetáceo, baseado na normativa do governo da Nova Zelândia (NEW ZEALAND, 1992). As interações não devem exceder 30 min (IBAMA, 1996), uma vez que a exposição prolongada de cetáceos aos barcos pode reduzir o tempo de descanso desses animais (FUMAGALLI *et al.*, 2018). Apesar de não haver um consenso entre os instrumentos legais, sugere-se a velocidade igual ou inferior a 4 nós, já que estudos apontam que embarcações que transitam a essa velocidade podem provocar menos respostas adversas às espécies-chave (SPROGIS; VIDESEN; MADSEN, 2020). O fornecimento de alimentos aos cetáceos deve ser proibido, com o objetivo de evitar prejuízo à saúde desses animais (VIDAL *et al.*, 2017).

Fêmeas com filhotes podem ser os alvos mais frequentes do TOC (BEJDER *et al.*, 2019). Já foram registradas mudanças no padrão de natação e mergulho, associadas a estratégias de evasão. Gastos de energia, em resposta à perturbação, podem, por sua vez, afetar o próprio desenvolvimento e sobrevivência dos filhotes (BEJDER *et al.*, 2019). Por esse motivo, fêmeas com filhote necessitam de medidas mais restritivas para garantir sua proteção (FIORI *et al.*, 2019) e, assim, sugere-se que os barcos mantenham uma distância ≥200 m de fêmeas com filhotes (NEW ZEALAND, 1992), e que o tempo de observação não ultrapasse 15 min.

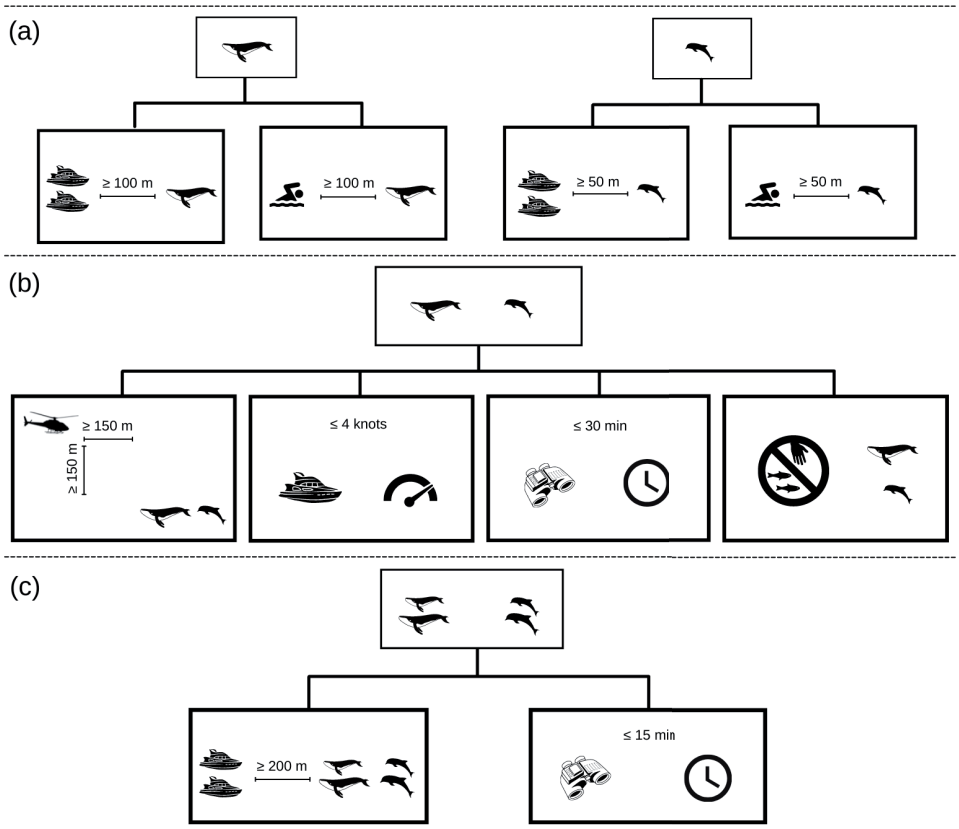

Figura 3 | Proposta de medidas a serem previstas em instrumento legal unificado para proteção de cetáceos: (a) Específicas, distância entre barcos e cetáceos e pessoas em natação e cetáceos, (b) Comuns, distância entre aeronaves e cetáceos, velocidade dos barcos, duração da observação e proibição de oferta de alimento, (c) Específicas para fêmeas com filhote, distância de barcos e duração da observação.

Fonte: Elaborada pelos autores, 2022.

5 CONSIDERAÇÕES FINAIS

Neste estudo, buscou-se responder quais são as áreas de referência do TOC no Brasil e suas principais espécies-chave. Foram identificadas 29 áreas de referência, distribuídas em 11 estados brasileiros, e sete espécies-chave do TOC no Brasil: baleia-jubarte, baleia-franca-do-sul, boto-cinza, golfinho-rotador, boto-da-tainha, boto-vermelho e tucuxi. Adicionalmente, investigou-se como o TOC é conduzido no Brasil. Essa atividade ainda não possui um instrumento de ordenamento legal unificado, embora, em nível nacional, conte com a Portaria Ibama nº 117, de 26 de dezembro de 1996, que visa prevenir e coibir o molestamento intencional de cetáceos encontrados em águas jurisdicionais brasileiras.

Considerando que as embarcações são uma fonte potencial de impactos negativos para os cetáceos, um instrumento de ordenamento legal unificado, de abrangência nacional, deve regulamentar, para todos os cetáceos passíveis de observação, por meio do turismo, distância entre barcos e cetáceos; distância entre pessoas em natação e cetáceos; distância entre aeronaves e cetáceos; número máximo de barcos em observação simultânea; velocidade dos barcos; duração da observação e proibição de oferta de alimento, além de uma regulamentação específica para observação de fêmeas com filhote.

Esse instrumento de ordenamento deve levar em consideração os estudos de alterações comportamentais em cetáceos, resultantes da interação com barcos. Na Portaria Ibama nº 117, de 26 de dezembro de 1996, fica instituído que compete às UC estabelecer tais limites. No entanto, existem áreas de referência do TOC que não estão legalmente protegidas como UC. Para promover, de forma integrada, a conservação de cetáceos e a sustentabilidade do ecoturismo, sugere-se que os instrumentos de ordenamento legal sejam a base das ações de capacitação continuada dos atores sociais e de pesquisa sobre indicadores ambientais para o monitoramento do TOC.

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Energy communities in sustainable transitions: the South American case

Comunidades energéticas na transição para a sustentabilidade: o caso da América do Sul

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ABSTRACT

Energy communities (ECs) have become an attractive scholarly target in recent years since they promote more sustainable, democratic, and decentralised electrical systems. Thus, a new research line around the alignments established by the European Union (EU) has arisen. Conversely, despite commonalities, Latin American initiatives and academic works still lack a standard distinctness. This work studies ECs' experiences in South America yielded in the literature, highlighting lessons, strengths, and weaknesses, under a sociotechnical and political lens. Thirty-eight articles indicated a variety of cases in the region. However, mainly off-grid isolated ventures focused on satisfying basic human needs, employing hydropower, solar, wind, biomass, and biogas technologies. Also, Brazil has indicated more profound advancements in on-grid ECs within urban settlements in the last few years. Nevertheless, there is a vast potential to develop new projects in the region.

Keywords: Energy communities. Energy transitions. Local transitions. South America. Sustainability.

RESUMO

As Comunidades Energéticas (CEs) têm chamado atenção acadêmica nos últimos anos, na medida em que promovem sistemas elétricos mais sustentáveis, democráticos e descentralizados. Um conjunto de estudos vem sendo realizado, acerca da temática, tomando como referência as definições estabelecidas pela União Europeia (EU). No entanto, as iniciativas latino-americanas carecem de um olhar específico, apesar

dos pontos em comum. Para preencher essa lacuna, este trabalho estuda experiências sul-americanas relatadas na literatura recente, enfatizando as lições, fortalezas e fraquezas sob uma lente sociotécnica e política. Trinta e oito artigos mostram uma diversidade de casos presentes na região. Tratam-se, principalmente, de empreendimentos isolados tipo off-grid satisfazendo necessidades humanas básicas, empregando tecnologia hidrelétrica, solar, eólica e de biomassa. Nos últimos anos, o Brasil mostra avanços no relativo às CEs on-grid em assentamentos urbanos. No entanto, ainda existe um vasto potencial para desenvolver novos projetos na região.

Palavras-chave: Comunidades energéticas. Transição energética. Transições locais. América do Sul. Sustentabilidade.

1 INTRODUCTION

The energy sector became pivotal in a world characterised by the climate crisis, the energy market volatility, and the rapid depletion of non-renewable resources (CHESNEY, 2020; FEIL; SCHREIBER; TUNDISI, 2015; MAX-NEEF, 2010; ROCKSTRÖM *et al.*, 2009). The current sustainable energy transition involves social, ecological, economic, and political dimensions, seeking to reduce carbon emissions by substituting fossil fuels with renewable sources. In the same way, customers' behaviour is changing. Electricity is becoming an essential type of end-use energy due to the high potential to reach high levels of efficiency (electrification of the economy) (RAM *et al.*, 2019; SANTOS, 2019). In 2000, the global share of electricity in final energy consumption was equal to 15%, reaching 20% today, expecting to reach 24% by 2040 if countries maintain their trends. The use of renewable sources, energy efficiency, and the electrification of the economy could account for 94% of emissions reduction committed to achieving the Paris Agreement limits (GIELEN *et al.*, 2019; INTERNATIONAL ENERGY AGENCY, 2020; SOVACOOL *et al.*, 2020).

Between 2007–2017, the Latin American and the Caribbean (LAC) region increased the non-conventional renewable energies (NCRE) use. New solar, wind, geothermal, and biomass projects emerged, but fossil fuels also expanded. Thus, total electricity production increased by 33% (POQUE GONZÁLEZ, 2020). Presently, the region faces at least three challenges: highly-centralised systems associated with mega power infrastructure, unequal access and accessibility, and low diversification of energy sources (IORIO; SANIN, 2019; POQUE GONZÁLEZ, 2020; WORLD ENERGY COUNCIL, 2019). In 2017, at least 12 million people in LAC had no access to electricity. While coverage in urban areas remains at 99%, it reaches 92% in rural areas (ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN *et al.*, 2019).

To promote more sustainable, democratic, and decentralised electrical systems, some policies – mainly European – have proposed encouraging Energy Communities (ECs) (ARIZTIA; RAGLIANTI, 2020; FUENTES GONZÁLEZ; SAUMA; VAN DER WEIJDE, 2019; GONZÁLEZ; WEIJDE; SAUMA, 2020; HELDEWEG; SÉVERINE SAINTIER, 2020; ROBY; DIBB, 2019). ECs are a group of citizens producing, managing, and using their energy in a defined local, geography, or place; customarily, in a distributed modality, and based on renewable sources (solar, wind, water, biomass, geothermal) and/or energy conservation/efficiency methods/technologies. This concept entails crucial issues such as resources management, social relations, human and environmental well-being, regulations, territorialism, and cultures (CEGLIA *et al.*, 2020; FUENTES GONZÁLEZ; SAUMA; VAN DER WEIJDE, 2019; KLEIN; COFFEY, 2016). Are there ECs in South America? How and by whom are they implemented? Which contexts have triggered these projects? Which lessons could we learn from these cases?

Answering those questions is not a simple task. European Union (EU) has promoted ECs as a pathway to the sustainable energy transition. Nonetheless, South American countries have no standard energy guidelines. Despite the reports of collective power generation projects in Argentina, Ecuador, Colombia, Chile, and Uruguay (FURTADO, 2020; FURTADO; PAIM, 2019), studies on the topic are still scarce. To fill this gap, this study aimed to analyse the literature on ECs' experiences in South America.

Social articulation is a critical issue in ECs configuration; consequently, we highlight sociotechnical and political dimensions, in line with Cherp *et al.* (2018) approach. We limit the analysis to studies focusing on projects with community participation.

This article is structured as follows: Section 2 presents the context of the South American sustainable energy transition. Section 3 shows the methods and materials driving the research. Then, Section 4 offers the main sociotechnical and political ECs' characteristics, country by country. Section 5 develops an interdisciplinary discussion around the main findings. Finally, in section 6, we conclude, encouraging the development of further studies related to the topic.

2 BACKGROUNDS

Energy systems undergo structural shifts in response to the current socio-ecological global challenges. For example, CO^2 emissions, according to 2010 values, must decrease by 45% until 2030 to achieve net-zero emissions in 2050 and mitigate the effects of climate change (BLONDEEL *et al.*, 2021). The current sustainable energy transition has at least four pivotal axes: decarbonisation, digitalisation, decentralisation, and democratisation (CUNHA *et al.*, 2021; GHENAI; BETTAYEB, 2021).

2.1 SOUTH AMERICAN ENERGY TRANSITION

South America has historically had a low-carbon matrix on the power generation side. Nevertheless, renewable sources have not yet displaced fossil fuels. In 2000, 77% of the electricity produced in the region came from hydropower, 20% from fossil fuels, 2% from nuclear plants, and 1% from biomass. In 2019, 57% of the electricity generated came from hydropower, 28% from fossil fuels, 6% from wind, 5% from biomass, 2% from nuclear plants, and 2% from solar sources (OLADE, 2022). Figure 1 shows the evolution of electricity generation in South America throughout the 21st century.

On the demand side, South America's share of electricity in final energy consumption accounted for 16% in 2000, increasing to 19% in 2019. It corroborated the global trend of electrification of the economy (OLADE, 2022). Throughout the 21st century, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela introduced renewable energy targets (KIEFFER *et al.*, 2016). Considering the size of their matrices, Uruguay, Chile, and Brazil were the most prominent in incorporating solar, wind, biomass, and geothermal sources between 2007 and 2017 (POQUE GONZÁLEZ, 2020).

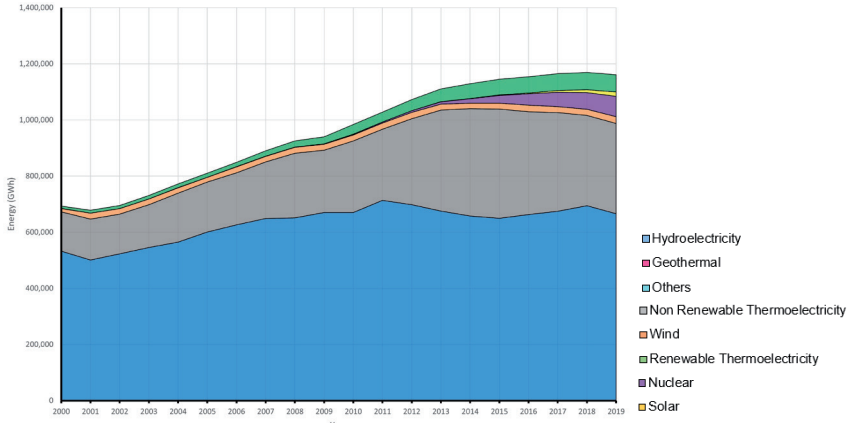

Figure 1 | Electricity generated between 2000 and 2019.
Source: Elaborated by the authors with data from Sielac (OLADE, 2022).

2.2 ENERGY TRANSITION AND ECS

The sustainable energy transition occurs at multiple levels. As shown in Figure 2, ECs are a local vector toward a low-carbon society. Also, renewable and distributed small-scale technologies offer broad opportunities for social empowerment. Moreover, collective, decentralised, and democratic energy projects are critical in the quest for sustainable futures and a just and inclusive energy transition (LODE *et al.*, 2022; THOMBS, 2019). Finally, Lode, Coosemans, and Ramirez Camargo (2022) pointed to socio-demographic factors as critical drivers in developing European energy cooperatives (a type of ECs). Thus, access to advanced education, information and communication, and satisfaction with housing and authorities correlate with the energy cooperatives' emergence.

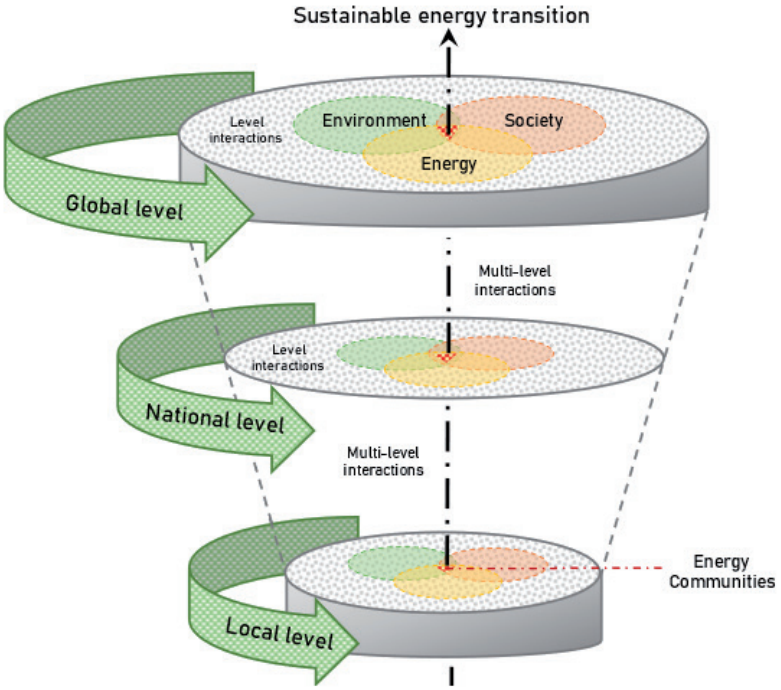

Figure 2 | Sustainable energy transition and the ECs' role.
Source: Elaborated by the authors.

3 METHODS AND MATERIALS

The main objective of this work is to examine ECs' experiences in South America, highlighting lessons, strengths, and weaknesses. We use a sociotechnical and political lens, limiting the search to the studies focused on projects with community participation. Then, a systematic literature review (SLR – (SORRELL, 2007)) tool carries the process of catching critical publications[1] studying ECs in the region. SLR concentrated on academic articles published between 2000 and 2020 on the Web of Science environment. The analysis focuses on electricity as an end-use energy resource; consequently, we do not consider heat-based literature.

To answer the central questions of this research, in a descriptive format, we expose the main sociotechnical and political characteristics of South American ECs. So, we identify commonalities and divergences between local, national, and regional levels. Afterwards, we develop a broad interdisciplinary discussion around emerging topics. Due to the bibliographical nature of this work, there are no ethical compromises or transgressions. We reference all documents used.

4 RESULTS

As shown in Figure 3, academic interest in South American ECs has been growing since 2010, indicating the great potential of this subject. Founded articles concern eight South American countries: Argentina, Bolivia, Brazil, Chile, Ecuador, Peru, Venezuela, and Surinam.

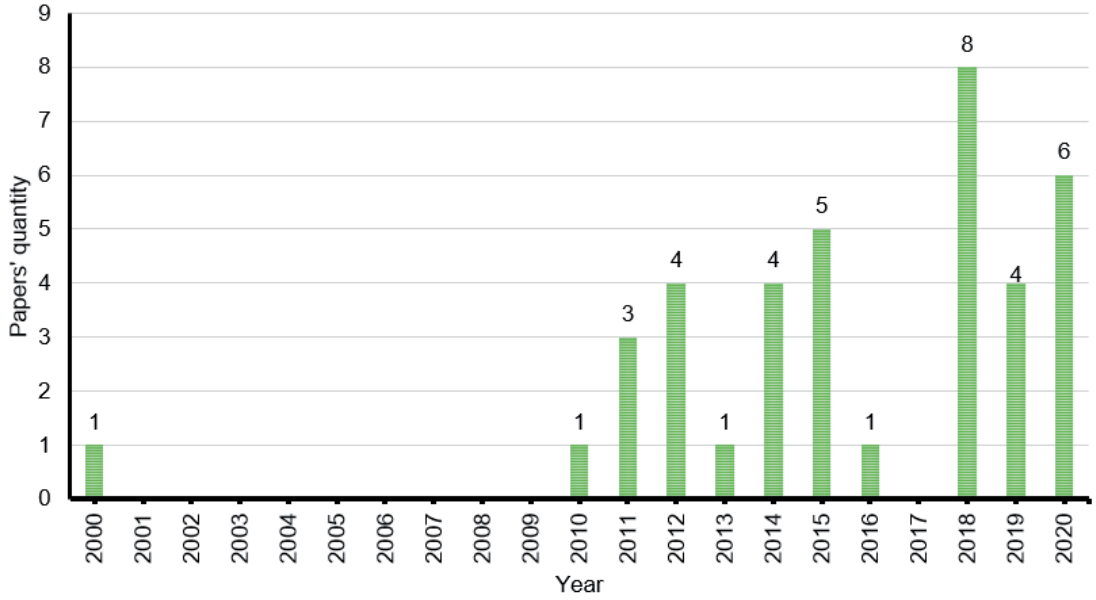

Figure 3 | South American ECs' articles per year.
Source: Elaborated by the authors.

According to the literature on the Argentine context, ECs may trigger a democratic, equitable, and collaborative pathway to the sustainable energy transition, empowering social arrangements. Electrical cooperatives operated in the generation, transmission, and distribution sectors since the 1920s-1930s, especially in small, isolated towns. Nevertheless, these initiatives disappeared over time, absorbed by public and private ventures. However, in the last decade, renewable energy sources and the evolution of power technology have reinforced electrical cooperatives, such as the case of the cooperative-like project located in Armstrong town, in the province of Santa Fé. This project consisted of a smart non-isolated grid composed of a 200-kW photovoltaic plant and 50 distributed solar home systems (SHS) of 1.5 kW (GARRIDO, 2018). Other projects based on biomass, biogas, and wind technologies have emerged under the same scheme. Still, the lack of regulations favourable to promoting ECs comprises a critical hampering factor in the country (KAZIMIERSKI, 2020).

One-third of the Bolivian population, located in rural areas, had no access to electricity in 2010. The literature on Bolivia focused on developing micro-hydropower (MHP) solutions of up to 100 kW to provide electricity for isolated communities. The geographical, economic, and environmental features made MHP a viable alternative to non-electrified remote communities. It facilitates a continuous electricity supply – in contrast with solar systems, which became more expensive due to the need for storage technology. Social participation led to the construction of cooperatives and local arrangements headed and supported by municipalities, non-governmental organisations (NGOs), and academic institutions. Still, disseminating and advancing technical knowledge is a critical issue (ARNAIZ *et al.*, 2018b; DRINKWAARD; KIRKELS; ROMIJN, 2010). As a challenge, local authorities must train operator teams, establish optimal tariffs to create financial reserves for maintaining the infrastructure and rely on the support of technical institutions and governments (ARNAIZ *et al.*, 2018a).

Due to geographical, technical, and economic issues, solutions to the lack of electricity in the Brazilian Amazon are not straightforward. São Francisco de Aiucá, a small floodplain village with 38 houses,

is partially electrified by SHS and a communitarian diesel generator (VALER *et al.*, 2014). Regarding photovoltaic solutions, the Aiha Central Indigenous State School, located in Xingu indigenous land, implemented a solar pilot project composed of three 270-Wp photovoltaic panels and enclosed devices to explore this technology and develop local knowledge. This community is isolated from the nearest electrical grid in Mato Grosso, so implementing electricity improved its educational tools (FIGUEIRÊDO NETO; ROSSI, 2019). Despite several Amazonian isolated projects based on biomass, photovoltaic systems, MHP, and hybrid solutions, not all guarantee community participation. For example, in some cases, customers acquire electricity by prepayment systems (SÁNCHEZ; TORRES; KALID, 2015).

There are eight mini-grids based on MHP cooperatives and community projects in the state of Pará, all of which located in Belterra, Santarém, and Placas Pará; namely: Açacal do Prata (80 kVA), Cachoeira Aruã (50 kVA), Corta Corda (150 kVA), Água Azul (120 kVA), Piranha (150 kVA), São João e Santo Antônio (150 kVA), Santa Rita (90 kVA), and Sombra Santa (160 kVA) (VAN ELS; DE SOUZA VIANNA; BRASIL, 2012). We also identified four other isolated projects on the Marajó Island in Pará, demonstrating different levels of community involvement jointly with academic and private entities. These were Marajó (200-kW biomass), Araras I (50-kW solar power), Araras II (25-kW wind power) and Caxiuanã (solar power) (BORGES; BARAÚNA; CHOTOE, 2015; PINHEIRO *et al.*, 2011, 2012). For example, a community cooperative performs the Marajó biomass project operation and maintenance (SÁNCHEZ; TORRES; KALID, 2015). At the opposite extreme of the country, groups of farmers implemented projects to produce biogas from organic waste. Thus, experiences such as those of São Roque Farm in Santa Catarina, and the Ajuricaba Condominium, in Paraná generate electricity by agro-waste (PASQUAL LOFHAGEN; BOLLMANN; SCOTT, 2018).

The adjustment of resolution no. 482 through resolution no. 687, in 2015, created a formal category for condominiums, consortiums, or cooperatives that generate and might introduce energy remains into the public grid; it was a crucial point for Brazilian ECs (LOTERO; DE SOUZA, 2020). As a result, the government registered ten cooperative on-grid projects in 2019. Among these, seven refer to solar cooperatives using photovoltaic generators that add up to 3.7 MWp of nominal power installed. Two hydropower plants add up to 6.5 MW, and one biomass plant is equivalent to 4.9 MW (SCHNEIDER *et al.*, 2019). Conversely, two condominiums in Juazeiro-Bahia installed 9,156 230-W photovoltaics panels on the rooftops of residences in 2014 (previous resolution no. 687) and six 5-kW micro-wind turbines in common areas, resulting in 2.1-MWp renewable generation capacity. However, the sale of energy modality was interrupted due to politico-institutional uncertainties (CUNHA *et al.*, 2021).

In Chile, photovoltaic infrastructure seems critical to ECs due to the country's geophysical features. Therefore, the Ayllu Solar project, located in the Arica y Parinacota region, adopts a co-construction scheme, whereby both the local community and the Energy Center of the Universidad de Chile participate in the design, operation, and final evaluation phases (MONTEDONICO *et al.*, 2018). Following this scheme, the Energy Center undertook the Huatacondo project in the Tarapacá region. This project consists of an isolated smart microgrid, including wind, solar, diesel sources, storage equipment, and demand-side management mechanisms (ALVIAL-PALAVICINO *et al.*, 2011; JIMÉNEZ-ESTÉVEZ, *et al.*, 2014; PALMA-BEHNKE *et al.*, 2011; RAHMANN *et al.*, 2016). It is expected to replicate the same procedure in Mapuche and Easter Island communities (PALMA-BEHNKE *et al.*, 2019).

An example of a bottom-up energy project is the Pan de Azúcar initiative. Here, a local fishermen's community in a coastal town of the Atacama Desert, northern Chile, proposed a shared project. The construction of two off-grid solar plants was driven by the need to provide electricity for domestic use and sustain fishing activities (ARIZTIA; RAGLIANTI, 2020). González *et al.* (2020) demonstrate the economic-strategic viability of community energy projects by comparing Chilean and Scottish institutional frameworks. Studies also indicate the existence of a cooperative in Coyhaique town, the Austral South of Chile, where citizens promote energy-saving and energy alphabetisation initiatives (BAIGORROTEGUI, 2018).

The literary production on ECs in Peru is rather extensive. The El Alumbre, Campo Alegre, and Alto Peru communities implemented three wind hybrid power projects in the Cajamarca region in the Northern mountains of Peru (3,800 – 4,000 m.a.s.l). The venture's management model is based on an independent micro-enterprise articulated with users' committees, municipalities, and NGOs (DOMENECH *et al.*, 2014; FERRER-MARTÍ *et al.*, 2012, 2013). El Alumbre uses micro-wind generators for each consuming point. Campo Alegre combines individual solar systems with a hybrid wind-photovoltaic solution. Due to the dispersion between households in Alto Peru, a wind power microgrid, a photovoltaic microgrid, an MHP, and an individual photovoltaic operate at different consuming points. Moreover, the Chorro Blanco, Tamborapa Pueblo, Suro Antivo, and El Regalado projects in the Cajamarca region employ MHP (FERNÁNDEZ-BALDOR *et al.*, 2014; FERRER-MARTÍ *et al.*, 2012; LILLO *et al.*, 2015a; YADOO; CRUICKSHANK, 2012). Pucara implemented a project that combines sanitation with energy services, employing MHP, separate photovoltaic systems, biodigesters, improved cookstoves, Trombe walls, and solar water heaters. Project administration is way more complex, integrating municipality, NGOs, users' committees, and operator systems (LILLO *et al.*, 2015b). Management and security are critical for the long-term sustainability of all these projects (DOMENECH; FERRER-MARTÍ; PASTOR, 2015).

Venezuela focused on rural and isolated electrification. A study on the theme approached the electrification of a Warao community, in the Orinoco Delta, in 2000 (MASI; CHASSANDE, 2000). According to it, implementing photovoltaic power systems comprised a community project involving culture, environmental matters, and local ecology knowledge, thus requiring the mobilisation of several community actors such as teachers, doctors, and inhabitants. To evaluate rural electrification programs based on renewable sources and investigate a sustainability pathway, López-González *et al.* (2018b) proposed a methodology assessed by four dimensions: environmental, technical, socioeconomic, and institutional. To this end, the authors tested the Sowing Light Venezuelan program for rural electrification launched in 2005, enabling community participation in management, operation, and maintenance through user assemblies (UA) and community councils (CC). Technological advances under such a scheme allow the implementation of hybrid microgrid systems (such as photovoltaic panels, batteries, wind systems, and diesel backup), which are environmentally friendly and socially well-accepted. Another study tested whether off-grid microgrid solutions would be more suitable than individual home systems (LÓPEZ-GONZÁLEZ; DOMENECH; FERRER-MARTÍ, 2018a).

Due to the Ecuadorian geography, the solar resource comprises a positive aspect. Quito's peripheral region lacks public infrastructure, so photovoltaic collective ventures represent a social response to meeting basic human needs such as security, education, and health (CRIOLLO ALVAREZ; MAKS-DAVIS; RODRÍGUEZ, 2020). The Community Access Resource for Electricity Sustainability (Cares) performed rural electrification in Guyana's Amazonian region. It guaranteed a bottom-up design of collective energy ventures while considering environmental, cultural, and identity issues (BLAIR; PONS; KRUMDIECK, 2019).

Table 1 shows works focused on political analyses of ECs. Table 2 points out on-grid projects studied under the sociotechnical lens. Table 3 presents the off-grid projects studied, focusing on Bolivia, Chile, Peru, Venezuela, and Guyana under a sociotechnical lens. Finally, table 4 shows off-grid projects focused on Brazil studied under a sociotechnical lens.

Table 1 | Works focused on political aspects of ECs in South American countries.

Author (s)	*Country*
(KAZIMIERSKI, 2020)	Argentina
(GONZÁLEZ *et al.*, 2020)	Chile

Source: Elaborated by the authors.

Table 2 | Works focused on on-grid projects studied from a sociotechnical perspective.

Project	*Technology*	*Estimated size*	*Country*	*Author (s)*
Armstrong	Solar	275 kW	Argentina	(GARRIDO, 2018)
Joanes	Hybrid	60.2 kW	Brazil	(SÁNCHEZ; TORRES; KALID, 2015)
Generic case	Solar	-		(LOTERO; DE SOUZA, 2020)
Coober	Solar	75 kW		(SCHNEIDER *et al.*, 2019)
Cooper Sustentável (São José)	Solar	1 kW		
Cooper Sustentável (Arcos)	Solar	0.25 kW		
Enercred	Solar	180 kW		
Compartsol	Solar	1.4 MW		
Sicoob Centro-Serrano ES	Solar	36 kW		
Coopercitrus	Solar	1 MW		
Sistema Sicoob ES	Solar	1 MW		
Juazeiro	Hybrid	2.1 MW		(CUNHA *et al.*, 2021)

Source: Elaborated by the authors.

Table 3 | Works focused on off-grid projects studied from a sociotechnical perspective. Part I: Bolivia, Chile, Peru, Venezuela, Guyana.

Project	*Technology*	*Estimated size*	*Country*	*Author(s)*
9 PRODENER projects and 1 Government/ private project	MHP	Totalising 353 kW	Bolivia	(ARNAIZ *et al.*, 2018a); (ARNAIZ *et al.*, 2018b)
Epizana, Chapisirca, Pojo, Flor de Mayo, Charía, Agua Blanca, Yanamayo, and Quinuni	MHP	Totalising 372 kW		(DRINKWAARD; KIRKELS; ROMIJN, 2010)
Challapata	Solar/Wind	---		(DOMENECH; FERRER-MARTÍ; PASTOR, 2015)
Turco	Wind	---		(DOMENECH; FERRER-MARTÍ; PASTOR, 2015)
Condor Sustainable Electrification Project - Huatacondo	Hybrid	134 kW	Chile	(ALVIAL-PALAVICINO *et al.*, 2011); (JIMÉNEZ-ESTÉVEZ, *et al.*, 2014); (JIMÉNEZ-ESTÉVEZ *et al.*, 2014); (PALMA-BEHNKE *et al.*, 2011); (RAHMANN *et al.*, 2016); (PALMA-BEHNKE *et al.*, 2019)
La Arena - Patagonia	Solar	17.4 kW		(ARIZTIA; RAGLIANTI, 2020)
Caleta Pan de Azúcar	Solar	---		(ARIZTIA; RAGLIANTI, 2020)
Alto Peru	Hybrid	2 kW	Peru	(DOMENECH *et al.*, 2014); (FERRER-MARTÍ *et al.*, 2012); (FERRER-MARTÍ *et al.*, 2013); (FERNÁNDEZ-BALDOR *et al.*, 2014); (LILLO *et al.*, 2015a); (DOMENECH; FERRER-MARTÍ; PASTOR, 2015)

Project	Technology	Estimated size	Country	Author(s)
Campo Alegre	Hybrid	3 kW	Peru	(FERRER-MARTÍ *et al.*, 2012); (FERNÁNDEZ-BALDOR *et al.*, 2014); (LILLO *et al.*, 2015a); (DOMENECH; FERRER-MARTÍ; PASTOR, 2015)
El Alumbre	Wind	4.3 kW		(FERRER-MARTÍ *et al.*, 2012); (FERRER-MARTÍ *et al.*, 2013); (DOMENECH; FERRER-MARTÍ; PASTOR, 2015)
Chorro Blanco	MHP	20 kW		(FERNÁNDEZ-BALDOR *et al.*, 2014); (LILLO *et al.*, 2015a);
El Regalado	MHP	12 kW		(FERNÁNDEZ-BALDOR *et al.*, 2014); (LILLO *et al.*, 2015a)
Suro Antivo	MHP	---		(LILLO *et al.*, 2015a)
Tamborapa Pueblo	MHP	40 kW		(YADOO; CRUICKSHANK, 2012)
Pucara	Hybrid	---		(LILLO *et al.*, 2015b)
Community of Macareo	Solar	---	Venezuela	(MASI; CHASSANDE, 2000)
Generic case	Hybrid	---		(LÓPEZ-GONZÁLEZ; DOMENECH; FERRER-MARTÍ, 2018b)
Kabakaburi	Hybrid	---	Guyana	(BLAIR; PONS; KRUMDIECK, 2019)

Source: Elaborated by the authors.

Table 4 | Works focused on off-grid projects studied from a sociotechnical perspective. Part II: Brazil.

Project	Technology	Estimated size	Country	Author(s)
São Francisco de Aiucá	SHS	4.6 kW	Brazil	(VALER *et al.*, 2014); (SÁNCHEZ; TORRES; KALID, 2015)
Aiha village	Solar	0.81 kW		(FIGUEIRÊDO NETO; ROSSI, 2019)
Marajó	Biomass	200 kW		(SÁNCHEZ; TORRES; KALID, 2015); (BORGES; BARAÚNA; CHOTOE, 2015)
São Francisco do Paroá	Biomass	80 kW		(SÁNCHEZ; TORRES; KALID, 2015)
Cachoeira de Aruã	MHP	50 kW		
Jatoarana	MHP	55 kW		
Novo Plano	MHP	76 kW		(SÁNCHEZ; TORRES; KALID, 2015)
Lençois	Hybrid	40 kW		
Tamaruteua	Hybrid	51 kW		
São Tomé	Hybrid	29.2 kW		
Praia Grande	Hybrid	22 kW		
Sucuriju	Hybrid	120 kW		
Vila Campinas	Hybrid	147.2 kW		
Araras	Hybrid	21 kW		
Equinócio	Solar	2.4 kW		

Project	Technology	Estimated size	Country	Author(s)
Açacal do Prata	MHP	64 kW	Brasil	(VAN ELS; DE SOUZA VIANNA; BRASIL, 2012)
Corta Corda	MHP	120 kW		
Água azul	MHP	96 kW		
Piranha	MHP	120 kW		
São João e Santo Antônio	MHP	120 kW		
Santa Rita	MHP	72 kW		
Sombra Santa	MHP	128 kW		
Araras I - Curralinho	Solar	50 kW		(BORGES; BARAÚNA; CHOTOE, 2015)
Araras II - Curralinho	Wind	25 kW		
Caxiuanã	Solar	---		
Santo Antônio	Biomass	50		(PINHEIRO *et al.*, 2011); (PINHEIRO *et al.*, 2012)
Ajuricaba Agroenergy Condominium	Biogass	83.2		(PASQUAL LOFHAGEN; BOLLMANN; SCOTT, 2018)

Source: Elaborated by the authors.

5 DISCUSSIONS

In this section, we analyse ECs, integrating social, environmental, and engineering fields as the central axes of sustainability science in the Anthropocene era (CLARK; HARLEY, 2020; LEVIN; CLARK, 2010). First, in the core of Figure 4, we resume the main findings of the searching process exposed in section 4. Then, from this diagnosis, we propose new fields to be discussed which emerge as weaknesses identified under the sociotechnical and political lens. Thus, section 5 involves both areas, highlighting emerging topics in a discussion that we do not expect to exhaust in this work.

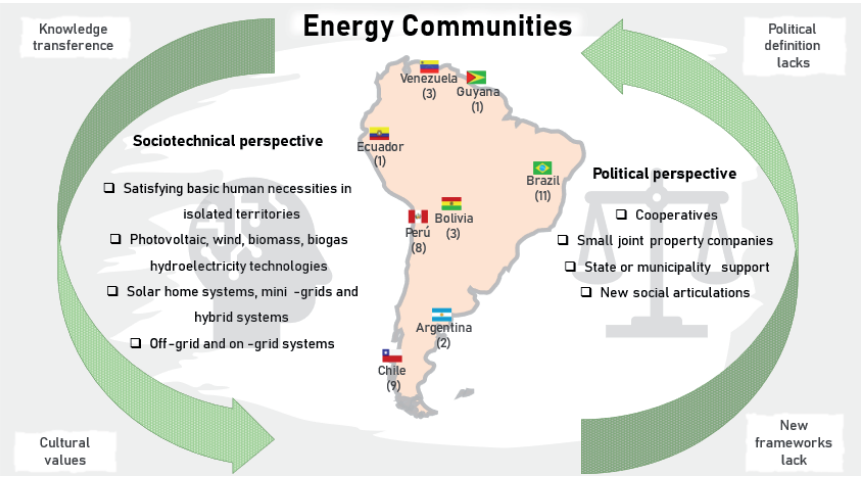

Figure 4 | Critical findings and emergent discussion points.
Source: Elaborated by the authors.

5.1 ENERGY POLICY

The property of essential services such as electricity has been highly discussed in the last decades. In the 1980s-1990s, a substantial part of South American electrical systems transited to liberalisation. Generally, the generation sector opened to competition, the transmission and distribution sectors

were submitted to a regulated monopoly, and the States assumed a regulatory role (IORIO; SANIN, 2019). After, in the 2000s, Bolivia and Venezuela nationalised their electrical systems. Meanwhile, other countries in the region maintained their liberalised and hybrid markets, setting reforms promoting the introduction of NCRE, overcoming market failures, and modernising frameworks (BALZA *et al.*, 2020; IORIO; SANIN, 2019).

21st South American regulations generally disregarded cooperative social bodies. Nevertheless, humans are cooperative animals (TOMASELLO, 2014), so issues related to meeting human needs always imply a deep community dimension. That is one of the sustains for ECs in South America. Before the historical lack of formal institutional bodies to govern and stimulate rural, isolated energy projects, local cooperatives emerged as a third way of ECs management (VAN ELS; DE SOUZA VIANNA; BRASIL, 2012). Likewise, South American ECs projects assumed the format of small private companies or were managed by bodies at the state or municipal level (LILLO *et al.*, 2015a).

5.2 HUMAN ROLE

We should understand the community beyond a social body that accepts or rejects a new technical solution designed and implemented by external technicians under co-opting participation schemes (BAIGORROTEGUI, 2018). Energy projects must incorporate local culture, worldviews, and social and environmental features. Local and indigenous communities have specific knowledge to protect biodiversity and ecological and cultural inheritance, which is essential to preserve land and mitigate environmental damages (FERNÁNDEZ-LLAMAZARES *et al.*, 2021). On the other hand, private companies may eventually abandon unprofitable projects, leaving human needs unmet if there are no satisfactory corporate profits (BORGES; BARAÚNA; CHOTOE, 2015).

In introducing new technologies into a community, especially in isolated localities without electrical service, multiple factors must be recognised since it is a cultural, social, and psychological process. Actors providing technical support must consider the specific cultural characteristics of the community (FEDRIZZI; RIBEIRO; ZILLES, 2009). Knowledge transfer is critical, as stated by the Brazilian educator Paulo Freire: "knowledge does not extend from those who think they know to those who think they do not know; knowledge is constituted in man-world relations, transformation relations, and is perfected in the critical problem-posing of such relations[2]" (FREIRE, 1983, p. 22).

5.3 SOME CASES

Most of the Brazilian Amazon zone is not covered by the Brazilian Power Electric System (Sistema Interligado Nacional - SIN). Naturally, this region has received particular academic attention (BACELLAR; ROCHA, 2010). Relying on fossil fuels-based isolated power systems or small-scale hydropower implies complex logistics processes. Cost-effectiveness and environment are critical issues, triggering an endless search for optimal renewable energy resources which demand community participation (ANDRADE; ROSA, 2011; GÓMEZ; SILVEIRA, 2012). The Amazon comprises a region rich in biodiversity and culture, but so do many others within South America. The Peruvian mountains, for example, present rugged geographical areas, which hampers the establishment of conventional energetic solutions and consequently stimulates collective responses. These facts show that the search for energy solutions with low environmental impact and synergic association with local lifestyles is fundamental to preserving human and natural heritage throughout the *Abya Yala*[3] region.

Most of the ECs research focused on the Brazilian and Chilean contexts – countries that have developed an institutional body to govern collective energy projects (POQUE GONZÁLEZ, 2021). In Chile, Law no. 21,118 of November 2018 modified the legislation to residential power generation, providing an institutional definition of collective owners of NCRE or efficient cogeneration infrastructure. These

power generators must be smaller than 300 kW (MINISTERIO DE ENERGÍA, 2018). Three years before, Brazil updated the normative resolution no. 482 of 2012, introducing the concept of shared generation. That is, the confluence of consumers into the same concession area through a cooperative or consortium with micro (equal to or smaller than 75 kW) or mini (upper than 75 kW, and equal to or smaller than 5 MW) distributed *generation infrastructure*[4] (AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA, 2016).

5.4 A BRIEF SOCIOTECHNICAL NOTE

Generally, the national energy statistics disregard isolated systems in evaluating emissions, risks, and improvements. However, as demonstrated here, ECs projects promote profound local, sustainable energy transitions. As well as biomass, the photovoltaic, wind, and hydro infrastructure, storage systems, demand response (DR) initiatives, and Energy Management Systems (EMS) might be other shared goods in on-grid ECs (CUENCA; JAMIL; HAYES, 2021).

Also, compared with *off-grid* ECs, *on-grid* ECs studies consider more techno-economic matters, such as energy losses at low voltage networks, additional costs for grid operators, and technical issues related to system stability, like controlling voltage or reactive power (CUNHA *et al.*, 2021). The relevance of having a clear regulatory framework that provides certainty and allows for the development of *on-grid* projects over time is evident in the case of Juazeiro. Moreover, information and knowledge are critical in localities where actors have financial autonomy, such as those formed by communities of farm managers.

Most ECs employ clean distributed resources, reinforce community arrangements, reject ancient pollutant technologies, and consider cultural and environmental issues. Given that local resources meet essential human needs in an environment characterised by a profound collaborative spirit, the focus of ECs agrees with the Human Scale Development of Manfred Max-Neef (MAX-NEEF; ELIZALDE; HOPENHAYN, 1998).

5.5 THE VALUE OF TERRITORIES

Many worldviews proper to the LAC regard the territory as more than physical space. A territory is a place produced from practices, knowledge, and know-how, establishing relations for the reproduction of life. As spaces that foster links, solidarity, exchanges, and communication, collective community learning – such as those in the core of indigenous, Black, peasant, and women's communities – the role of academia, social movements, alliances, and networks are pivotal in South American energy transition (ROCA-SERVAT; PERDOMO-SÁNCHEZ, 2020). Then, sparking a multi, inter, and transdisciplinary debate about LAC's conception of energy tasks is essential. At the local level, ECs articulate a social, ecological, and technical niche to promote a sustainable alternative to established systems (or *status quo* regimes). Further research must assimilate ontological and epistemological dimensions of sustainable joint energy projects (MEYER; VILSMAIER, 2020; TIRONI; SANNAZZARO, 2017).

Abya Yala's knowledge and wisdom urge for the deconstruction of the Western insights of development and sustainable development[5], claiming for a pluriversal world in transition to ethical, just, and socio-ecological sustainability (SOVACOOL *et al.*, 2017; VANHULST, 2019; VÁSQUEZ-FERNÁNDEZ; AHENAKEW PII TAI POO TAA, 2020). An example is the *Buen Vivir* (BV), an Andean and Amazonian traditional worldview whose main axes are identity, equity, and sustainability. BV postulates a lifestyle in harmony with oneself, society, and nature (GUEVARA; CAPITÁN, 2015). The Brazilian indigenous leader Ailton Krenak discloses: "the BV can be the difficult experience of maintaining a balance between what we can get from life, from nature, and what we can give back. It is a balance, a very sensitive balance, and not something that we access by a personal decision"[2] (KRENAK, 2020, p. 8). However, the BV represents a small part of a pluriversal set of rich worldviews from the original population of the region.

6 CONCLUSIONS

The social arrangements configured to generate and manage electricity are a longstanding practice in South America, mainly due to the region's rugged geography and the incapacity and non-availability of extended national grids to reach every human settlement. Thus, initially, ECs literature focused on projects seeking to address the issue of access to electricity in isolated localities (*off-grid* projects). Nevertheless, since 2018, the literature has approached ECs projects as a viable on-grid alternative within urban settlements.

Remote and rural non-electrified settlements still exist, and the region's availability of distributed energy sources is prominent, having a high potential to develop new ECs. Also, there is a possibility of reinforcing ECs due to the emergence of cheaper NCRE technologies (VAN ELS; DE SOUZA VIANNA; BRASIL, 2012). Moreover, grid extensions are not always viable (economically), such as when isolated communities have a low-density population (FERRER-MARTÍ *et al.*, 2012). On the other side, the modernisation of sociotechnical and institutional landscapes has enabled new on-grid initiatives, mainly powered by social, economic, political, and environmental reasons (CUNHA *et al.*, 2021; SCHNEIDER *et al.*, 2019). Nevertheless, there is a lack of political definitions, promotion, and regulatory frameworks for ECs in the region.

ECs projects in South America are complex, implying at least biophysical, geographic, ecological, and social components (RAHMANN *et al.*, 2016). ECs are a core where actors, empowering forces, and social networks interact with technical solutions, the environment, and local resources. Converging toward standard scholarly definitions and interpretations of ECs in South American countries is an exciting challenge. As presented in the discussion section, Brazilian and Chilean political-institutional status on ECs give a chance to develop a starting point for comparative studies.

Before the immeasurable diversity of cases explored, this study does not exhaust such a topic; the field to be explored within the subject is still rather broad. The current scenario is characterised, among others, by the socioeconomic damage arising from the Covid-19 pandemic and the global task of facing climate change (POQUE GONZÁLEZ; SILVA; MACIA, 2022). Thus, the worsening of draughts and shifts in the water cycle and the nuances specific to each South American government pose enormous inter-and transdisciplinary challenges to the science. It could represent an unusual opportunity for promoting pivotal sustainability shifts, a breakpoint to a profound transition (SCHOT, 2020). Going deeper into ECs is a necessary and ambitious undertaking in the South American region.

Electricity can significantly benefit the population's quality of life (BORGES; BARAÚNA; CHOTOE, 2015; DINIZ *et al.*, 2011). Similarly, ECs can improve community health, children's education, household income, comfort, and communication (FERRER-MARTÍ *et al.*, 2012). From this perspective, isolated rural and peripheral urban settlements (typical in South America) such as Brazilian Favelas, often excluded from the technological development of conventional power grids, could find a sociotechnical solution in ECs (DW BRASIL, 2021).

NOTES

1| Searching arrangement: ((Community) OR (cooperative)) AND ((Energy) OR (Electricity)) AND ((Argentina) OR (Bolivia) OR (Brazil) OR (Chile) OR (Colombia) OR (Ecuador) OR (Guyana) OR (Paraguay) OR (Peru) OR (Suriname) OR (Uruguay) OR (Venezuela)).

2| Our translation, from Brazilian Portuguese.

3| The term *Abya Yala* is a Guna Indigenous term used to refer to what is known today as Latin America (VÁSQUEZ-FERNÁNDEZ; AHENAKEW PII TAI POO TAA, 2020).

4| Micro- and minigeneration must be renewable or quality cogeneration. Minigeneration considers hydropower lower than 3 MW.

5| Sustainability has often been defined in two ways: (1) as dynamic stability in social and ecological systems and their interactions and (2) the meeting of the needs of the present human population without compromising future generations (SALOMAA; JUHOLA, 2020). These meanings might be somehow related to the worldviews of *Abya Yala*. Nevertheless, when combined, the terms sustainability and development induce critical divergences, for sustainable development models are usually rooted in Western paradigms (VÁSQUEZ-FERNÁNDEZ; AHENAKEW PII TAI POO TAA, 2020).

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Anti-crisis strategy of state governance in the wartime: an example of Ukraine

Estratégia anti-crise da governança de Estado durante uma guerra: o exemplo da Ucrânia

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ABSTRACT

Russian military invasion of Ukraine became yet another reminder to humanity about how fragile our world is and how it requires unity and partnership to confront global humanitarian challenges and ensure sustainable development goals. The article analyses the historical context of the establishment of Ukrainian statehood, provides a situational assessment of the current state of the economy and environmental hazards in Ukraine and investigates anti-crisis «success stories» of other countries where reforms were based upon a market-oriented doctrine of New Public Management (NPM). On this basis, a strategy of changing an existing system of state governance in Ukraine was elaborated by the authors. In the development of the presented strategy a cybernetic approach was used whereas the conceptual framework for it was formed by the provisions of sustainable development in terms of the civic society. Adherence to the concept of sustainable development is regarded by the authors as an essential condition for overcoming the war-induced socio-economic crisis.

Keywords: Anti-crisis strategy. State governance. War. Socio-economic crisis. Environmental disaster.

RESUMO

A invasão militar russa na Ucrânia tornou-se mais um lembrete para a humanidade sobre como nosso mundo é frágil e como requer unidade e parceria para enfrentar os desafios humanitários globais e garantir as metas do desenvolvimento sustentável. O artigo analisa o contexto histórico do estabelecimento do Estado ucraniano, fornecendo uma avaliação situacional do estado atual da economia e dos riscos ambientais na Ucrânia e investiga «histórias de sucesso» anti-crise de outros países onde as reformas foram baseadas em uma doutrina orientada para o mercado da Nova Gestão Pública (NGP). Com base nisso, foi elaborada pelos autores uma estratégia para mudar um sistema de governança estatal existente na Ucrânia. Para a estratégia apresentada, foi utilizada uma abordagem cibernética e um quadro conceitual foi formado pelas disposições de desenvolvimento sustentável consideradas pela sociedade civil. Os autores consideram a aderência ao conceito de desenvolvimento sustentável como uma condição vital para superar a crise socioeconômica causada pela guerra.

Palavras-chave: Estratégia anti-crise. Governança do Estado. Guerra. Crise socioeconômica. Desastre ambiental.

1 INTRODUCTION

Irrespective of its socio-economic development level, every country in the contemporary world may become an object of military aggression on the part of neighbouring or geographically remote countries. «Today's world has the technological conditions (war artefacts) to self-destruct» (BURSZTYN *et al.*, 2022, p. 6). At the same time, the economic weakness and political instability of the country considerably increase its chances to become a victim of aggression from the side of a more economically advanced and well-armed state. The history of international conflicts is replete with examples of obliteration of sovereign states at the time when, being weakened by internal contradictions, they became the object of encroachment on the part of stronger and more militant geopolitical «players».

The day of the 24th of February 2022, when the Russian Federation invaded Ukraine, became a departure point for a rapid escalation of conflictogenity across all continents. There are currently 18 conflict «hotspots» across the world, along with another 45 «frozen» armed conflicts. The prospects of wrapping up or «freezing» the most dangerous conflict «hotspots» in the contemporary world with the help of the most effective mechanisms of state governance have recently been studied by Baconi (2016), Cohn-Sherbok and El-Alami (2015), Fraser (2015), Nabatchi and Goerdel (2011) and Stashkevych (2022). In addition, considerable attention on the part of contemporary scholars, in particular Brewster (2015), Carranza (2018), Sasikumar (2019), and Yusuf and Kirk (2016), is given to the issue of increasing nuclear threat.

Due to the global economic fallout from the war in Ukraine, the risks of «thawing» these conflicts increase dramatically. In the view of the International Monetary Fund (IMF) experts, the Russo-Ukrainian war in the long term may cause a fundamental shift in the global economic and geopolitical order in case of a systemic failure in energy trade and disruption of food supply chains (KAMMER *et al.*, 2022).

Maintaining an entire world within a paradigm of sustainable development and, correspondingly, overcoming a profound economic crisis, which presently threatens the world, is only possible under substantial improvements to the model of governance universally adopted in democratic countries.

How does a socio-economic crisis, which emerges in the country as a result of the armed conflict at an international level, changes this governance model?

War does not generate new, specific principles and mechanisms of state governance, but it updates, transforms and optimises the already existing ones that are required at the time. For instance, at first

sight, in the conditions of war imperative, command and control methods of governance appear to be the most efficient. However, simultaneously, they are efficient only at the first stage of a socio-economic crisis caused by war or in the case of a swift end to this war. If the conflict acquires a protracted nature, different governance approaches and leverages of state influence become more in-demand.

Regrettably, the process of transformation of the system of state governance in the conditions of prolonged wars as well as cause and effect relations between the emergence of armed conflicts (both internal and international) and specific models of state governance are presently insufficiently studied.

Within the scope of the presented paper, the authors focused on the concept of New Public Management (NPM), the underlying concept of which is the achievement of maximum efficiency of state governance, political pluralism in decision-making, a delegation of authority to the lower levels of administrative hierarchy and balanced division of power as well as the increased participation of civil society in governance.

2 METHODOLOGICAL PROCEDURES

A methodological foundation of our study is the concept of sustainable development of humanity, its key provisions being introduced in an outstanding collective research effort by Meadows, Donella H; Meadows, Dennis L; Randers, J titled «The Limits to Growth» published in 1972. It contained several forewarnings about the long-term implications of preserving the then-existing trends in the spheres of global demographics, use of natural resources, environmental pollution and liberal market-based methods of economic activity in industry and agriculture. But unfortunately, not all countries heeded these warnings. Therefore, the world continues to be shaken by wars and economic crises.

In the course of the study, the authors analysed the strengths and shortcomings of the state governance system in Ukraine and the changes that have occurred within it since its accession to independence until now. The monitoring of the efficiency of state governance in Ukraine has been conducted based on data from World Governance Indicators (WGI), a ranking initiated by Daniel Kaufmann (Natural Resource Governance Institute (NRGI) and Brookings) and Aart Kraay (World Bank, Development Economics) in 1999. It evaluated 215 countries and territories following such criteria as Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. As the originators of the ranking suggest, these aggregate indicators combine the views of many enterprises, citizens and expert survey respondents in industrial and developing countries. They are based on over 30 existing data sources that report the views and experiences of citizens, entrepreneurs, and experts in the public, private and NGO sectors from around the world on the quality of various aspects of governance. The WGI draw on four different types of source data: *surveys of households and firms*, including the Afrobarometer surveys, Gallup World Poll, and Global Competitiveness Report survey; *commercial business information providers*, including the Economist Intelligence Unit, IHS Markit, Political Risk Services; *non-governmental organisations,* including Global Integrity, Freedom House, Reporters Without Borders; *public sector organisations,* including the CPIA assessments of World Bank and regional development banks (WGI, 2021).

The analysis of the system's current state would be impossible outside the context of geopolitical, economic and existential «shifts» on a global scale caused by the Russian military aggression against Ukraine; hence, further consideration was also given to analysing them.

Studying the evolutions of the market-oriented doctrine of NPM, we were relying upon the cybernetic approach, which postulates the principle of feedback which may be both positive and negative. Contemporary American researcher M. Maruyama called systemic conditions, which occur as a result of negative feedback a «morphostasis», systemic conditions which occur as a result of positive feedback – «morphogenesis» (MARUYAMA, 1963). Another scholar – G. Myrdal – established an identifiable

pattern, the veracity of which was proved by the authors of the presented paper on the example of implementation of NPM in Ukraine: free market relations function morphostatically in developed countries (i.e. they stabilise the economy, ensure positive impact upon it) and, contrariwise, function morphogenetically (i.e. shatter an already existing instability and aggravate the already «weak points») concerning the economy and social structure of underdeveloped countries (MYRDAL, 1981).

In the formation of an anti-crisis strategy of changing the state governance in the conditions of war, the authors proceeded from the fact that the state governance, with its set of values being aimed at sustainable development, stipulates the search for the most optimal, humanitarian-oriented ways of transformations in the society within three closely intertwined dimensions – economic, social and environmental. In the official documents that define strategic intentions of the state governance, the value aspects are formulated as principles and priorities for action. Hence, the authors suggested that an anti-crisis strategy of state governance in wartime comprises two efficiency indicators: «Principles» and «Processes». According to the first indicator, the authors consolidated the principles into two groups: common (that concern all three dimensions) and partial (inherent in a particular dimension). Provisions of our strategy according to the two indicators have been elaborated with an account of Ukrainian realities. Nonetheless, they may be similarly utilised as a universal tool for optimising the system of anti-crisis state governance by other countries.

3 RESULTS

3.1. THE SYSTEM OF GOVERNMENT UNDER CRISIS CONDITIONS: PAST EXPERIENCES

Self-organisation, nonlinear development, and disruption of informational and cultural boundaries between countries represent critical features of the contemporary global society once identified by M. McLuhan as a «global village» (MCLUHAN, 1967). Crises are a natural occurrence for such a society; hence, such a model of state governance is required to respond promptly to economic, socio-energy and moral value-related «cataclysms».

Under crisis conditions, the significance of state governance influence increases substantially, particularly from forecasting and strategic anti-crisis planning, monitoring, and funding of innovative governance decisions. Without efficient institutions of governance, sustainable economic and social development of the state is essentially impossible. Namely, these institutions can release intrinsic growth energy, driving the society out of stagnation with minimal deformations of the social space. At the same time, in the contemporary world, the issues of internal development of a specific country are being decided without considering the views of a vast range of concerned parties at the intergovernmental level: representatives of the business community, authorities, various civil society institutions.

From the standpoint of efficiency of measures for crisis management, the USA's experience during the Great Depression of the 1930s proves to be the most useful. In 5 years of crisis, the investment activity within the country dwindled by 5 times; the GDP reduced by half; over 3 thousand banks ceased their activity. The number of unemployed exceeded 17 million people. The New Deal by F.D. Roosevelt became the very instrument that not only enabled to curb the crisis but also provided a powerful momentum to reforming the entire system and transforming the USA into a country ranked first in the world in terms of economic development.

The anti-crisis measures in the USA were implemented in four major directions: 1) the reform of financial and credit relations, reduction in public spending, cessation of unjustified subsidising, and pricing liberalisation; 2) increased supervision and control in the sphere of trading of securities, tighter state control over price parities; 3) consistent anti-inflation policy; 4) neutralisation of mafia criminal activities and total war on corruption. The state budget was introduced with a specific item

of expenditure in the form of provisions for anti-crisis measures funded by a newly administered Reconstruction Finance Corporation. The mass withdrawal of deposits was banned for the population. Excise taxes were increased, and the fiscal policy was strengthened; it became a norm to hold public trials against the violators of financial, tax and labour laws. Various institutions for crisis management were established, among them The National Recovery Administration (NRA), The Works Progress Administration (WPA), and The Agricultural Adjustment Administration (AAA). The establishment of the Civilian Conservation Corps (CCC) and the Federal Emergency Relief Administration (Fera) had become instrumental in overcoming the crisis. Its significant role was played by the social insurance system based on the principle of future generations compensating for the expenses of social subsidies in the period of crisis. Most researchers believe that the New Deal brought about innovative changes at the time and ensured the preservation of the country's existing constitutional, economic and social structure.

Another instance of recovery from the crisis may be observed in Great Britain's experience of the mid-1970s-1980s. A precondition for the emergence of this crisis became the establishment in the western world of a model of a welfare state developed in a joint effort by American scientists, Nobel prize laureates J. Buchanan and P. Samuelson as well as L. Johansen (Sweden), R. Musgrave (USA) and A. Peacock (Great Britain) *et al.* This model found its practical application in the socio-economic programme by W. Beveridge, the eponymous Beveridge Report, which was presented to the British parliament in 1942 and was later fully implemented by an already post-World War II Clement Attlee's government in 1951. It became the baseline model for public services around Great Britain. Its underlying principle – state-guaranteed universal, equal access to quality public services according to need, not ability to pay; funding of public services primarily from the state budget and provision of such services by government institutions.

The centralisation significantly improved the quality of public services, ensured standardisation of price formation, unified procedures for all individuals and equal access to them. Conversely, all this led to increased government spending and, correspondingly, tax hikes, making the system inflexible and unreceptive to ever-changing needs on the local level. Apart from this, centralised government control and standardisation did not encourage the growth of innovation and the responsibility of citizens for the common good. A similar situation could be observed in other West European countries: The Federal Republic of Germany, France, and Sweden. Globalisation on par with increasing international competition has also played a prominent role by prompting national states to modernise public governance, combat corruption and minimise administrative barriers. All this, combined with the growing demands of citizens for the quality of public services against the background of the economic crisis which engulfed the developed West European countries in the mid-1970s-1980s, caused a new wave of administrative reforms bound together by an ideology of NPM. This novel approach, stipulated by the economy's needs, called into question all the fundamental precepts and principles of traditional public governance.

The doctrinal baseline of NPM was comprised of the following conceptual provisions: a priority of professional hands-on management responsibility for the implementation of goals of state governance and vested with broad administrative autonomy; transparent standards and indicators of state governance (predominantly quantitative metrics); focus on controlling and monitoring the result, not the initial conditions or preservation of state governance procedures; decentralisation and disaggregation of governance structures, their division into a compact, controlled structural units with individual budgets; introduction of corporate governance framework into state administration with clearly separated areas of responsibility of individual governance structures and granting them a broadest possible autonomy; downsizing the state apparatus and limiting its impact on the economy.

New market-oriented NPM doctrine established its leading positions not only in science and politics but also became an ideological foundation for activities of neoliberal political forces which came to power in the leading Anglo-Saxon countries – Great Britain and the USA and consequently spanned

the developing countries in Latin America, Africa, Central and Eastern Europe, Asia (including post-socialist countries). A prominent role in the global expansion of NPM was played by international organisations, such as UNDP, IMF, the World Bank, WTO and others, which actively supported the NPM-inspired reforms. The implementation of NPM was also solicited by international consulting companies whose services were used by the developing countries in elaborating their national programmes for modernising public administration.

To a large extent, NPM is based on the presumption of the advantage of market-based mechanisms over state-related ones. Margaret Thatcher's government, which conducted a series of effective reforms, is rightly considered a «trailblazer» of NPM. For instance, in 1988, Thatcher's government initiated a programme related to fundamental reform of state governance with the presentation of the report «Improving Management in Government: The Next Steps». As a result of the programme's implementation, the functions of government policy and rendering public services were institutionally separated. Cumbersome government departments were reorganised, whereas to render public services, over 130 agencies were created, with their work organised according to business management principles. In this way, structural and functional separation of the government policy and the sphere of public services became one of the significant innovations of NPM.

With all its positive effects in countries with a developed democracy, implementing NPM in developing countries brought about ambiguous consequences. There, a «governance gap» was observed when the governments acting in these countries were not capable of ensuring the necessary reform measures and activities while the society was not ready for them. As an outcome, the state apparatus weakened, which allowed local corrupted elites to seize power in their regions. In several countries, this led to significant internal contradictions within society and even armed conflicts at the international level. The most severe effects were observed in the countries with a high level of corruption in the state apparatus and security agencies – the DRC (formerly until 1997, Zaire), Iraq, Afghanistan, Liberia, Colombia, etc.

3.2. UKRAINE: A DIFFICULT PATH FROM GAINING INDEPENDENCE TO THE ARMED CONFRONTATION WITH THE AGGRESSOR STATE

The reform of the state governance system came with a considerable delay in the post-socialist countries, including Ukraine – in 1998. Its objective was to create a state governance system that would comply with European standards for a democratic state governed by the rule of law and possessing a market economy. The concept of the administrative reform in Ukraine at the time stipulated such changes: goal-oriented governance; standardisation and regulation of public services and their rendering at multifunctional service centres; rendering of public services and information about them in electronic form; optimisation of functions of executive power and counteraction against corruption; establishment of effective interaction between the executive authorities and the society. An inhibiting factor for progressive NPM ideas became the fact that they were being implemented based on the institutional platform of the post-Soviet period, which possessed the «vices» common to all countries of the former USSR: non-transparency, weak regulation of administrative and governance processes, uncertainty and irrationality of the functional structure of state governance, excessive and inefficient government intervention, willfulness and corruptness of government officials.

A peculiarity of the administrative reform in the then Ukrainian state was an effort to combine the reception of the global trend for NPM (with its key points of market competition, managerialism, and focus on the consumer of public services) with addressing the challenges that evolutionarily should have predated the implementation of NPM but for a variety of historical reasons were not duly solved. This specifically concerns the creation of solid rational bureaucracy in its classic Weberian sense. At the beginning of the 2000s, the administrative system of Ukraine was not yet prepared for market competition and boosting productivity. In contrast, it required basic consolidation, surmounting

the legal chaos and elaborating executive discipline standards on all levels of state governance. As a result, neoliberal principles of economic efficiency of state governance, ideas of managerialism and quality public services naturally receded into the background against the top priority at that time – the establishment of national statehood and civic society.

The first clear evidence of the formation of a new European-value oriented society became the Orange Revolution of 2004 – a campaign of protests, public rallies, strikes and other acts of civil disobedience in Ukraine as a fierce reaction to mass vote rigging conducted by the authorities during the presidential elections. The change of the ruling elites, which occurred as the consequence of these events and a subsequent European integration policy of Ukraine, became a fertile ground for modernisation and transformation of state-level and municipal-level institutions, as emphasised by Khadzyradieva, Sitsinska and Slukhai (2021). As a result, Ukrainian society proclaimed its readiness to conduct a qualitative reform of local administration based on principles of subsidiarity, regionalisation, decentralisation and sustainable development.

The formation of a new European society in Ukraine has been taking place in a state of permanent resistance to indirect and, later on, direct and open aggression on the part of the Russian Federation. The watershed years for the entire country proved to be 2013-2014, when the Revolution of Dignity occurred as a protest against an unlawful dispersal of peaceful students, and civic activist demonstrations and military activities started in the east of the country following Russia's efforts to instigate and provide weapon supply to separatist sentiments among the local population. In the open Russian military aggression conditions, Ukrainians are fighting for their freedom and state integrity with weapons.

Indicators of quality of governance (Table 1) cited in the comprehensive periodic study World Bank Group «Worldwide Governance Indicators» affirm positive developments within this domain in Ukraine over the last 20 years.

Table 1 | Changes regarding the quality of governance in Ukraine from 2000 to 2020 (data sourced from «Worldwide Governance Indicators»)

№	Indicator	Year	Number of Sources*	Governance Score** (-2,5 to 2,5)	Percentile Rank***	Standard Error****
1	Voice and Accountability	2000	8	-0,61	30	0,18
		2020	11	0,09	51	0,12
2	Political Stability and Absence of Violence/Terrorism	2000	4	-0,41	32	0,34
		2020	7	-1,16	12	0,23
3	Government Effectiveness	2000	6	-0,70	26	0,20
		2020	8	-0,36	38	0,22
4	Regulatory Quality	2000	8	-0,53	29	0,23
		2020	9	-0,30	40	0,19
5	Rule of law	2000	11	-1,11	14	0,16
		2020	12	-0,67	27	0,14
6	Control of Corruption	2000	8	-1,15	8	0,18
		2020	11	-0,78	23	0,14

Notes:
** Shows the number of individual data sources on which the aggregate indicator is based.*
*** Estimate of governance measured on a scale from approximately -2.5 to 2.5. Higher values correspond to better governance.*
**** Indicates Ukraine's rank among all countries in the world. 0 corresponds to the lowest rank, and 100 corresponds to the highest.*
***** Captures the precision of the estimate of governance for each country. Lower values indicate a higher precision. Standard errors are related to confidence intervals reported elsewhere: a 90% confidence interval is the estimate of governance +/- the standard error multiplied by 1.645.*

Source: WGI http://info.worldbank.org/governance/wgi/Home/Reports.

Indicator 1, which demonstrates the ability of the country's citizens to participate in selecting their government and other public authorities, the level of independence of media and the level of civil liberties have displayed an improvement from -0,61 to -0,09. The Government Effectiveness (Indicator 3) has also improved: the indicators increased from -0,70 to -0,36. Government effectiveness indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. According to Indicator 4, which estimates the ability of the government to implement sound policies and regulations that promote private sector development, positive changes have taken place in the last 5 years and proved to be less significant (from -0,53 to -0,30). As per Indicator 5 – efficiency and predictability of legal framework, crime rate, the efficiency of the police, courts, etc. – the indicators improved from -1,11 to -0,67. Virtually identical value of positive changes has been observed in respect of combating corruption (from -1,15 to -0,78) – as per Indicator 6.

Negative dynamics (from -0,41 to -0,16) have been displayed within the scope of Indicator 2, which measures the stability of government institutions, the likelihood of resorting to drastic policy shifts, destabilising or overthrowing the government through violence. Such an outcome proves logical, considering two revolutions and an armed conflict in the country's east occurred between 2004 and 2021.

Consequently, the data provided in Table 1 assert the predominantly positive changes in the quality of state governance from 2000 to 2020. Even though these positive governance quality developments may hardly be labelled as rapid and extensive, they manifest as systemic and consistent. Furthermore, despite all the difficulties encountered in the development of the state after the second bloody revolution and the outbreak of hostilities in the east of the country, since 2014, an installation of innovative forms of municipal democracy has begun. It has been actively proceeding, particularly in such instances as electronic petitions, electronic elections, citizen's (participatory) budget, etc., based upon the reception of the positive experience from European and other foreign countries with a high degree of democratic development as well as accounting for recommendations of the Council of Europe.

In 2021 the government of Ukraine adopted the Public Administration Reform Strategy until 2025, which defines its priority as building a competent service and digital state in Ukraine which ensures the protection of the interests of its citizens based on European standards, best practices and experience. In contrast, among its key objectives, it lists the development of effective and accountable state institutions that shape public policy and successfully implement it for the state's sustainable development.

The positive developments in the state governance system were halted due to Russia's armed aggression.

With the outbreak of military action in February 2022 and until presently, an increasingly worsening situation has been observed in the economy and the state of the environment, which became a passive and the least protected victim of this war.

As a result of military activities, the air, the water and the soil are being contaminated, and flora and fauna are being exterminated. In addition, there arise risks of damage to particularly hazardous industrial installations: chemical industry enterprises, nuclear power stations and other installations, which represent a potential source of danger to the population.

Since the beginning of the full-scale Russian invasion, the natural environment in Ukraine has sustained over 300 cases of ecocide (UNN, June 6, 2022), significantly impacting food security within the country and across all European countries. This is the first international military conflict in the past 20 years which caused such considerable and irreparable damage inflicted to the environment. Generally, no military conflict may be referred to as local regarding the natural environment, given that conventional

borders cannot separate ecosystems on the map. If the natural balance in one geolocation is ruined, it will inevitably impact the others. For example, the war has caused multiple deaths of dolphins off the coasts of Turkey and Bulgaria; thus, its consequences are far more profound.

From the very first days of the invasion, the experts of the Ministry of Ecology and Natural resources of Ukraine have been recording the damage to the natural environment inflicted by explosions at fuel and lubricant depots, oil products storage, and air strikes against enterprises which utilise dangerous chemical agents in their production, damage and destruction of sewage treatment facilities as well as damages to the soil cover, forest fires – specifically in the locations of natural reserve funds. In the view of the head of the Ministry Roman Strilets, the environmental destruction in Ukraine threatens to destroy 2,5 million hectares of European environmental network, specifically 160 sites within the Emerald Network (territories and objects protected at the pan-European level) as well as 17 Ramsar sites covering 627,3 thousand hectares (wetlands of international importance). The Minister emphasises that due to Russia's actions, at least 20% of the natural protected areas of Ukraine have been jeopardised (MINISTRY OF ENERGY AND ENVIRONMENT PROTECTION OF UKRAINE, 2022).

The Russian Federation is conducting military operations in natural protected areas of international and European importance, subsequently destroying the habitats of rare and endemic animal species. Further, deforestation is occurring, which may lead, specifically in the south of Ukraine, to wind erosion and desertification. Ukraine's almost 3 million hectares of forests are in war-torn regions. For comparison, this nearly comprises the territory of Belgium.

Missile attacks against petroleum storage depots and industrial enterprises, as well as the heavy shelling of infrastructural objects and residential buildings in Ukraine, eventuate in the atmospheric air pollution by harmful substances.

Emissions into the atmosphere caused by the detonation of missiles and projectiles are carried over, deposited as sediments and have a detrimental impact on the territories of other countries.

The situation with the economy of Ukraine is likewise highly complex. Its downturn is anticipated at the level of 30-50%. The disrupted logistics require investments to restore international trade, and a demand for social relief and recovery is growing. Budget revenues have fallen into the risk zone, the expenditures are high, and they keep growing. The fuel crisis is choking off business activities and adaptation of the economy to the conditions of war. The government allocates the largest share of budget expenditures for defence purposes, law enforcement and social support. To equalise budget expenditures and recover the economy over the next several years can be made possible under increased international financial support.

The state governance system, which existed in Ukraine before the beginning of the military invasion, requires overhaul and optimisation with an account for wartime requirements and those humanitarian challenges and threats that the society faced with the outbreak of war.

3.3 AN ANTI-CRISIS STRATEGY OF STATE GOVERNANCE IN THE CONDITIONS OF THE WAR-INDUCED SOCIO-ECONOMIC CRISIS

In September 2015, at the 70th Session of the UN General Assembly in New York, a Summit on Sustainable Development was held where new agenda for sustainable development was approved. The resulting document of the summit, "Transforming Our World: The 2030 Agenda for Sustainable Development", adopted 17 sustainable development goals (SDGs) and 169 targets. As a result, Ukraine, similarly to other UN member states, joined the global process of ensuring sustainable development, and since then, an inclusive process of adaptation of SDGs has been initialised within the country.

Throughout the time of adaptation of the SDGs in Ukraine, 42,6% of resources were channelled to implement Goal 16 of the SDG – «Peace, justice and strong institutions». In the conditions of an ongoing war and a socio-economic crisis that it caused, the interpretation of targets (the total of 9 targets were defined for Ukraine) within the framework of the given goal must be significantly revised. For instance, Goal 1 – «No poverty» – will now become a key target for state governance, whereas the allocation of costs for its implementation before the outbreak of military action amounted to only 0,7% of the state budget. Due to the massive destruction of infrastructure, another top-priority goal becomes SDG 6 – «Clean water and sanitation», which includes the provisions for availability and sustainable water management and sanitation (previously, 3,3% of the state budget).

SDG 9 – «Industry, Innovation and Infrastructure» and SDG 8 – «Decent work and economic growth» both possess outstanding significance in ensuring progress to achieving all SDGs by creating prerequisites for the growth of added value and the GDP. The latter of the two goals acquires particular relevance considering the necessity of returning Ukrainian refugees to their homes. For Ukraine, which currently (as of March 2022) has 12 million forcibly displaced persons, with 3,5 million of those having fled abroad, the provision of jobs and the resumption of industrial operations have become a specific requirement (REZNIKOVA; PANCHENKO, 2022).

In such a way, the war introduced significant amendments to principles and the process of state governance, which is reflected in the provisions of the anti-crisis strategy elaborated by the authors.

3.3.1 «PRINCIPLES»

General provisions:

- Unity of purpose at all levels of administrative hierarchy;
- effective planning, which allows achieving balance between the measures of economic «survival» of territories, support of business, ensuring environmental security and social protection of the population;
- centralisation of power in the short term (up to half-year) with a mandatory return to decentralisation in the long term. It must be noted that during peacetime, the efficiency of governing a democratic state is ensured primarily through the formation and maintenance of «safeguards» against excessive centralisation of power. It is achieved by separating powers, delegating authority, and specific political levers of counteracting such centralisation. In the conditions of war and a socio-economic crisis induced by it, the centralisation of power becomes an indispensable provision for mobilising the resources of state governance. However, it may become detrimental if it remains prioritised in subsequent stages of the crisis unfolding.

Partial provisions (about economic, social and environmental dimensions):

- maximum mobilisation of internal resources (productive, intellectual, energy, financial, enforcement, etc.);
- prioritised funding of armed forces;
- ensuring uninterrupted functioning of systemically vital financial institutions of the state;
- minimisation of government institutions' regulatory impact on the economy's operational functioning. First and foremost, this concerns downsizing the number of controlling bodies and their authority and the liberalisation of permitting procedures.

- the principle of decarbonisation and decentralisation of the energy sector. The green recovery must include Ukraine's accelerated phase-out of fossilised fuels, particularly its importation. Ukraine, similarly to developed democratic countries of Europe, must solve the challenge of transitioning to 100% renewable energy sources by 2050 and gradually opt out of using nuclear energy for power generation. Any investments into the energy sector must be based on the necessity to phase out fossil fuels.

3.3.2 «PROCESS»

To optimise the process of governance in the conditions of the war-induced crisis, it is imperative to observe the following provisions:

Provision 1. Flexible situational response to the challenges of wartime with a simultaneous concentration of efforts of government authorities on prospective directions of political and socio-economic development;

Provision 2. Timeliness and adequacy of response to threats; mobility in utilising the available resources; consistency in the implementation of decisions taken; promptness and efficiency in correcting errors. All these requirements may be unified in a critical notion of «balanced efficiency». «Sluggish» governance system of the state in the conditions of crisis is jeopardy to society, business and citizens as a whole.

The decisions taken by the government of Ukraine two weeks after the outbreak of war (from February 24th to March 10th) testifies to its capacity for swift and radical actions. On the other hand, the problem of filling the state budget has been successfully solved using emission: planned issuance of military bonds for the amount of 400 billion UAH – 26% of 2022 budget expenditures, 10% of GDP (ECONOMIC TRUTH, February 26, 2022); through external loans and aid packages (the obtainment of which was successful due to timely efforts of the state leadership) there has been achieved a frail yet, given ongoing active hostilities, macroeconomic stability.

Provision 3. An adequate financial foundation is formed due to building up and developing an intrinsic production potential. However, 50% and more economic decline requires a considerable public investment in constructing new types of factories and production cycles for added value chains «from scratch» in cooperation with countries friendly to Ukraine. Reforms of state governance and liberalisation, when conducted in the condition of the destruction of budget-forming enterprises and disruption of value and supply chains, will be «caught in limbo» without producing any tangible result.

Provision 4. Optimisation of the governance process in the long term (over half-year) stipulates elaborating a well-coordinated interaction between government authorities and local self-government based upon the principle of subsidiarity.

This provision attains particular significance under martial law when all the elements in the power hierarchy naturally gravitate towards the centralisation of governance decisions. Hence, an absolute priority for the warring country lies in ensuring maximum efficiency of local government authorities in managing the resource potential of corresponding territories and establishing coordinated activities of all government institutions to timely secure the pressing military needs and economic recovery.

Provision 5. Governance influence is directed at balancing the containment of inflation and the necessity to minimise losses in production output volumes. Achieving the said balance is possible provided the reduction in the regulatory impact of government institutions on the operational functioning of the economy. This concerns foremost the downsizing of the number of controlling bodies and their authority, liberalisation of permitting procedures, lowering of customs barriers or their complete

elimination (excluding the cases of protection of domestic market from subsidised import or import from unfriendly or hostile countries).

Provision 6. Reduction of the tax burden on the economy, particularly through VAT differentiation (primarily the introduction of the zero rate for socially significant groups of commodities), substantial reduction of taxes on labour: USC (unified social contribution) and PIT (personal income tax), leastwise for small businesses.

Shocks in the energy and food markets resulted in price hikes for essential commodities. Therefore, it is necessary to steer further towards normalising the lending conditions or suspending such internal inflation factors as salary and housing rental. Furthermore, optimisation of the system would be facilitated with the launch of automatic budgetary stabilisers such as reducing tax payments. Presently, In Ukraine, fuel taxes have been reduced; a drastic downsizing in the number of regulatory documents has been reached (by 30 times less); finally, the government has taken an unprecedented decision to cancel the VAT and introduce the turnover tax for the duration of the state of war.

Provision 7. Focus on restoring the human capital of the country.

Returning Ukrainian refugees to their homeland and providing them with employment and housing is a top-priority condition for the subsequent recovery of the country's economy. Similar attention is required by the internally displaced persons, specifically the entrepreneurs. To efficiently employ their potential and, correspondingly, ensure their complete adaptation to new conditions, local government authorities must work resolutely to preserve and restore the region's business environment. This includes the formation of adequate production infrastructure, for instance, by creating industrial, technology and science parks, industrial zones, etc. and the launch of mutually agreed relocation of enterprises and their potential employees, development of objects of related social, engineering and marketing infrastructure.

Provision 8. In the medium term, transition to alternative energy sources with low emission levels (such as wind, solar and nuclear energy). At the same time, in the short term, in the capacity to temporarily safeguard fossil fuels from sources other than Russia. This provision complies with SDG 13, 14, 15 («Climate action», «Life below water», «Life on land»).

Climate change and the war against Ukraine have a direct interconnection and common roots. This refers to the fossil fuel and morbid addiction of the world's countries to it. Oil and gas constitute 60% of Russian export. The war unleashed by the Russian Federation not only harmed Ukraine but also jeopardised the implementation of climate goals and the ability of the world to adapt to climate changes.

Most governments and companies anticipate that the energy crisis caused by the war in Ukraine would nonetheless accelerate the world's transition to alternative energy sources with low emission levels (CUMMINS; CHERNEY, 2022). For instance, the EU’s plan REPowerEU proposes to replace approximately 100 billion cubic meters of Russian-produced gas until the end of the year with 50 billion cubic meters through the supply of liquified natural gas from other countries, with the rest being ensured through the use of wind and solar energy generation, energy saving and diversification of sources of pipeline gas.

Simultaneously, to implement the presented goal, there is a necessity for quick investment into the development of energy efficiency and energy saving, ensuring increased energy security and enhancement of climatic measures for every country. In order to implement these ambitious goals in unstable and war-affected countries and to endorse adaptation to climate change at the local level, specialised international institutions must develop and implement transparent and flexible access mechanisms to climate finance.

Provision 8. Development of sustainable and decentralised governance systems to ensure food security.

Currently, the system based upon large-scale and monocultural production centralises logistics and processing represents a weak spot for Ukraine. The aggressor can instantly decimate it with corresponding systemic implications for all supply chains in Ukraine and worldwide. Hence, developing and maintaining flexible, sustainable and decentralised systems of managing the agro-food sector must become a top priority for an agriculturally oriented country, Ukraine.

4 FINAL CONSIDERATIONS

In 1991 when Ukraine became independent, along with other countries of the former Soviet Union, it possessed vast natural resources for further development, a robust industrial basis and an advanced military-industrial complex. Nevertheless, as a consequence of the splicing of the then government with financial and industrial oligarchy and their criminal activities concerning the utilisation of state resources in their vested interests, reformation of the system of state governance in the country had been ongoing at a slow rate and had no systemic nature. Implementation of NPM in Ukraine at the beginning of the 2000s, when the administrative system and the society were not yet evolutionarily ready to such extent of change, proved to have a morphogenetic effect – it further weakened the already «weak points» in the economy and social structure of the country. At the same time, in developed countries such as Great Britain and the USA, the ideology of NPM already two decades earlier became an effective tool in the hands of governments that allowed not only to recover the economy from the crisis but also to ensure its steady growth for a long term. The analysis of «stories» of implementing NPM in the developed (Great Britain) and the developing country (Ukraine), provided in the given paper, affirms the validity of the pattern revealed by Myrdal about the morphostatic and morphogenetic impact of market relations on the system of state governance.

The experience of Ukraine is furthermore of interest as it allows to investigate the processes of transformation of the state governance system in the conditions of a protracted military conflict. Since 2014 Ukraine has remained in a state of permanent resistance to indirect and, since February 2022, direct and open aggression on the part of the Russian Federation. Consequently, over the last eight years, a unique model of state governance has been formed therein, under which the motion towards liberalisation of socio-economic relations and particular progress of inclusive institutions of democracy has been occurring predominantly from the «lows», i.e. by the growing civil society. At the same time, for the «highs» of the state governance, a general approach has remained a centralisation of political and administrative practices as an instrument of maximum mobilisation of internal resources to ensure the Ukrainian state's repulsion of external military aggression both in its indirect and direct form.

The strategy of state governance in wartime, suggested by the authors, stipulates maintaining the balance between the wartime needs for centralisation of power and a natural demand of the society for the reduction of the regulatory influence of government institutions upon the development of the economy. The analytical data provided in the given article permits to significantly extend the frontiers in understanding cause and effect relations between the outbreak of armed conflicts (and crises related to them) along with overcoming them and implementing a particular model of state governance in the country.

Ukraine made its civilisational choice in favour of democracy and presently goes down a troubled path of literal trial by fire, similar to what all modern democratic states experienced in their past. The war unleashed by the Russian Federation against Ukraine is a war of freedom against slavery, security against a constant threat, sustainable development against degradation, of the future against the past. Historically, the clash of two fundamentally opposed value domains in the 21st century is occurring precisely on the border between Ukraine and Russia, between the country of great potential and the country of the «embalmed» past. The war between these countries is waged for the sake of the new architecture of Europe and the world as a whole. Thus, Ukrainians are now giving their lives not only for the sake of protecting the sovereignty of their state but also to protect the values and the priorities of

a civilised civic society which chose the path of sustainable development for peace, equity, and justice and safe existence of the humankind.

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Zero waste in the apparel industry: limitations and alternatives

Zero waste na indústria do vestuário: limitações e alternativas

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ABSTRACT

The Zero Waste approach applied to garment manufacturing promises the elimination of textile waste in the production process, making the process more sustainable. This article contributes to aiding textile manufacturing companies in applying more sustainable techniques to reduce waste. Therefore, the main objective is to identify critical aspects and limitations of the design and the patternmaking process using the Zero Waste approach to apply in the garment industry in large-scale production. The study initiates with zero waste bibliography research and identification and analysis of the proposals of the fashion designers who use the Zero Waste approach to garment design and pattern making. As a result, the article presents critical aspects and limitations of the approach and discusses viable alternatives for its implementation in the large-scale garment manufacturing process.

Keywords: Zero waste. Apparel. Industry. Textile sustainability.

RESUMO

A abordagem Zero Waste (ou zero resíduo), aplicada à produção do vestuário, promete a eliminação dos descartes têxteis durante o processo produtivo, promovendo ações em direção à sustentabilidade. Dentro dessa perspectiva, o presente artigo contribui para que empresas de confecção têxtil possam aplicar processos mais sustentáveis, visando à eliminação dos resíduos. Para tanto, como principal objetivo, o trabalho busca identificar aspectos críticos e limitações do processo de criação e modelagem,

usando a abordagem Zero Waste, para sua aplicação na indústria do vestuário, na produção em larga escala. Para isso, a pesquisa partiu de bibliografia relacionada ao tema e da identificação e análise das propostas dos principais designers do vestuário que utilizam as técnicas de criação e modelagem com a abordagem Zero Waste. Como resultado, o artigo apresenta uma discussão sobre os principais aspectos limitantes e alternativas viáveis para sua implementação no processo produtivo de confecção de vestuário em larga escala.

Palavras-chave: Zero resíduo. Vestuário. Indústria. Sustentabilidade têxtil.

1 INTRODUCTION

The concept of sustainable development is not new and can be defined in several ways; the World Commission gave a famous and appropriate definition of Environment and Development in 1987. According to this commission, sustainable development means development that meets the needs of the present without compromising the needs of future generations (MUTHU *et al.*, 2012).

In environmental sustainability, economist studies and environmentalists recommend avoiding waste generation in manufacturing or disposal of products after use (CUC; VIDOVIC, 2011). However, the textile industry generates about 15% of waste from what it produces between cutting and garment production. Therefore, considering the total global textile production in 2015 was about 400 billion square meters, taking into account the waste generation estimate is 15%, it estimates that the textile industry generates around 60 billion square meters of waste (RISSANEN; MCQUILLAN, 2016).

The creation of Brazilian Law No. 12,305 of 2010, which support the National Policy on Solid Waste (PNRS), led the garment industries to seek alternatives for the appropriate and responsible management of textile waste. There are several points of attention at the stages and resources used and produced by the textile and garment industry. Using renewable and biodegradable fibres, recycling alternatives, minor use of chemical substances in textile crops, and little use of energy and water, among other factors, can improve these points (FLETCHER; GROSE, 2011). Also, according to the same authors, changes in clothing design are necessary to reduce or eliminate waste and offer to the market garments with timeless concepts, greater durability and useful life. In addition, the consumer is also responsible; he should seek a more thoughtful consumption that minimises waste and support sustainable industry initiatives.

Thus, the designers are essential agents in the search for more sustainable fashion, proposing innovative alternatives in garments with style, quality, and durability, which minimise or eliminate waste from the moment of conception of the garment to the stages of its manufacture. One of the approaches that seek the total elimination of waste in the design and construction of garments is the Zero Waste approach, which acts directly on the source of waste and can be considered clean technology, with production processes modified considering the environment (PEREZ; CAVALCANTE, 2014).

Several fashion designers have been using the Zero Waste approach, in which the creative process is executed together with the steps of pattern making and marker making for the textile cut. It is worth remembering that, in the process of conventional fashion design, these steps are carried out independently and usually executed by professionals of different specialities. The sketch is generally used for creation and establishes the details, colours, and aesthetic aspects. However, it is impossible to identify and calculate the waste in the sketch phase; it is only possible to figure in the following stages when pattern making and cutting are carried out. In another way to these hierarchical patterns of the conventional process steps, the practice of creating Zero Waste fashion acts dynamically in its processes. The steps traditionally performed separately are necessarily performed together. Therefore, the patternmaking step becomes an integral part of the process and actively contributes to generating ideas. Such a change of standards highlights the designer's need to be open to the possibilities and accept the risks and challenges of this practice (RISSANEN; MCQUILLAN, 2016, p. 123).

However, despite the numerous proposals for Zero Waste creation and pattern making already presented by several designers, many questions arise about its application in the large-scale production process. The time required for the creation process increases as well as its complexity. These techniques are unconventional and unknown to most textile manufacturing professionals; applying the Zero Waste approach concepts, both in the creation and later stages, requires several adjustments in the production. The main issue, perhaps the most discussed, is related to the pattern grading stage. At this stage, the patterns produced in the base size are enlarged or reduced to meet the size grid offered by the company. Usually, a first size (base size) is produced with the concepts of the Zero Waste approach, and in grading, it is not always to keep all the grid sizes with the same idea. However, the graduation of patterns is not the only issue to be resolved by garment companies that apply this approach. There are other limiting factors in using this approach on a large scale.

Recently, other researchers have studied pattern grading. For example, ElShishtawy *et al.* (2021) conducted a systematic literature review on cutting and marker-making processes and Zero Waste apparel design. As a result, unlike the conventional process, the authors reinforce the importance of integrating processes in this approach, indicating that future research should try to incorporate the cut-and-marker algorithms in the Zero Waste design processes. In addition, Ramkalaon and Sayem (2021) investigated the application of the Zero Waste pattern cutting concept in large-scale production to optimise the production process and achieve zero waste. The authors developed a framework to implement the concept in different size grids.

After that, they tested the framework on two types of clothes in various sizes. For this process, Ramkalaon and Sayem (2021) used digital tools to cut and design the patterns; physical prototypes experimented with the fit of the clothes. As a result, the authors achieved a 98% yield in fabric usage because 85% is already considered impossible. Finally, Carrico *et al.* (2022) investigated the effectiveness of the Carrico Zero Waste Banded grading technique in the scale production of size-grade garments. The technique was taught to six designers who applied it to scale production. According to the authors, the technique was effective in reducing fabric waste.

Considering the recent research on the subject, the relevance of some limiting aspects that can disturb the implementation of the Zero Waste approach on a large scale in industries, such as grading, marking, and cutting off pieces, and the search for solutions is noticed that minimise these issues. However, the works cited are restricted to certain problems, although essential. Still, they do not care about the complete process, the issues that permeate the Zero Waste approach, from the creative process to the operational aspects. In this way, the present work proposes identifying the main critical or limitations of applying the technique of creating and cutting garments with the approach without residue (Zero Waste) applied to the clothing industry. Furthermore, seek and present alternatives to overcome these limitations, still that partially. Therefore, the relevance of this work lies in offering textile manufacturing companies alternatives to produce more sustainable fashion through Zero Waste pattern making and creation.

2 THE ZERO WASTE APPROACH APPLIED TO CLOTHING DESIGN AND MANUFACTURING

According to Rissanen and McQuillan (2016), the term Zero Waste came up in the fashion field around 2008 as a new phenomenon. However, the same authors argue that Paul Palmer, founder of the Zero Waste Institute in 1970, one of the first to use the term Zero Waste, has published many critiques about waste in modern industry.

It is worth mentioning that "although the term zero waste fashion design is new, the practice is as old as dressing the body with skins and cloth" (RISSANEN; MCQUILLAN, 2016, p.11).

In antiquity, weaving was common on looms whose dimensions were reduced, so it was woven in reduced pieces joined by seams, minimising the waste of the cut of the wide fabric. At another time, rectangular fabrics without any transformation were wrapped around the body in different ways (BOUCHER, 2012, p. 24). In later historical periods, many garments were designed on the total use of the fabric without producing waste.

After the industrial revolution, with cheaper fabrics, this practice was abandoned. Instead, fashion began to fulfil new aesthetics that could not be linked to waste-free production. However, the concept of zero waste reappears in the 20th century (YIELD EXHIBITION, 2011). It began to be remembered more intensely in the second half of the century, with the advent of the concept of sustainability, after the Stockholm Conference, in Sweden, in 1972 (BERLIN, 2012). From then on, the contemporary pioneers of zero waste appear. Firmo (2017) presents the English artist Zandra Rhodes, who, in the 1970s, brings the production of clothing using the Zero Waste approach. During this period, Rhodes worked with geometric cuts in her creations, resulting in pieces that involved the body without any seam.

Aakko and Niinimäki (2013) explain that this zero waste method comes into fashion to eliminate fabric waste in the production of clothing from the creation of the design and state that, for this approach, it is essential to integrate pattern making with the design process, in contrast to the conventional practice of pattern making after the product creation. Rizzi, Anicet, and Meurer (2017) point out that the designer must conceive a product already thinking about patternmaking that can generate no waste and if any waste is produced, used in the garment itself. Thus, the patternmaking integrated into the product creation process differentiates the Zero Waste fashion design process from the conventional process.

Several designers work on integrated creation and pattern making using the Zero Waste approach. Some names have already been mentioned, such as Holly McQuillan and Timo Rissanem. However, professionals like Yeohlee Teng, Julien Roberts, David Telfer, Caroline Briebe, Carla Fernández, Tara St. James, Mark Liu, and several others have developed experiments using the Zero Waste approach (LIU, 2017; MCQUILLAN, 2011; RISSANEN; MCQUILLAN, 2016; ROBERTS, 2013; TENG, 2018; YIELD EXHIBITION, 2011). These designers seek to create innovative garments and propose different techniques to achieve their goals. Only Rissanen and McQuillan went beyond the creative processes among the designers mentioned. They systematised the concepts and practices of the Zero Waste approach in clothing, discussing critical or limiting aspects for its application in the industry on a large scale.

3 MATERIALS AND METHODS

The developed research adopts the qualitative model, based on observation and associative analysis of data, being the study modality of recognition, a subgroup of the qualitative method. The delimitation of the research area of interest is at the intersection of fashion design concepts with sustainability concepts. Therefore, the work is inserted in the sustainable perspective of creating and patternmaking garments.

The central part of the research was based on bibliographic material, aspects related to sustainability, the Zero Waste patternmaking phenomenon, and the relationship of these concepts with fashion design. From this search, it was possible to identify how prominent designers in the market apply the Zero Waste patternmaking techniques. This analysis allowed the authors to identify a good part of the limitations of this approach. Further, we developed prototypes of some garments, reproducing the process proposed by the designers, following their instructions (when present). Two designs created by Holly McQuillan and Timo Rissanen were chosen. They are the leading designers of the Zero Waste approach. Although not detailed in this article, developing these prototypes allowed us to identify additional limiting aspects of the Zero Waste patternmaking and creative process.

The prototypes were developed using a three-dimensional patternmaking mannequin, in natural size (40) and reduced size (50% of reduction, size 40) and raw cotton fabric, of medium weight. Photographic and written records were made of the reproduced prototype. The procedure allowed the elaboration of critical analysis on the tested patternmaking techniques.

4 RESULTS AND DISCUSSIONS

The bibliographic research made it possible to identify the main critical and limitation aspects that must be observed in applying the Zero Waste approach in the industrial production of clothing, from the creative process (associated with the pattern making and marker making) to its production stages. However, the experiments with the techniques proposed by the Zero Waste designers were essential to understanding the complexity of the patternmaking process of unconventional garments. Therefore, the integrated process of creation and patternmaking was used in the experiments.

During the elaboration of the prototypes, following the creative processes proposed by the designers, relevant aspects that were not found in the literature search emerged. Hence, the two garments chosen, made by designer McQuillan, presented in Rissanen and McQuillan (2016): the "Trapeze Sleeveless Tunic" (Figure 2) and the "Spiral Trouser" (Figure 1).

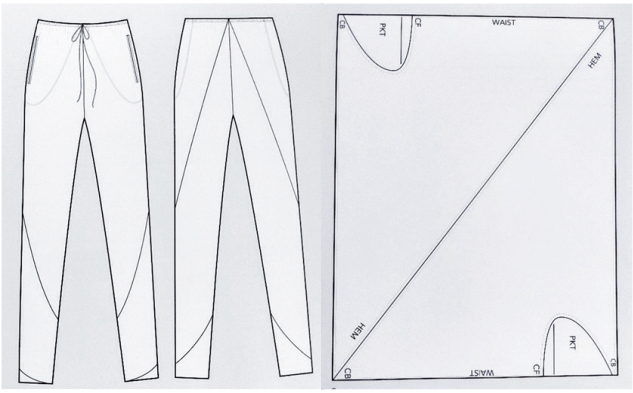

Figure 1 | Technical drawing and pattern making of the Spiral Trouser, developed by Holly McQuillan, using the Zero Waste approach.

Source: Rissanen e McQuillan (2016, p. 115).

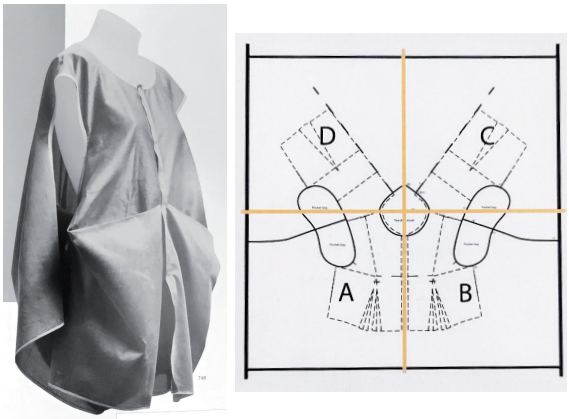

Figure 2 | Trapeze Sleeveles Tunic and its pattern making, developed by Holly McQuillan, using the Zero Waste approach.

Source: Rissanen e McQuillan (2016, p. 97-96).

In constructing the two prototypes, we observed the full use of the fabric. Despite simple pattern making, several important ramifications emerged, indicating limitations of the approach for its application in large-scale garment production.

The first aspect observed in both prototypes was the small number of instructions about the garment development process. There are several steps for elaborating each of the garments. However, many details are absent from the instructions or have dubious explanations. Because of that, the reproduction process required several tries until we could understand and replicate the garment correctly. In the case of the trapeze tunic, the publication used as a base does not present any other image of the garment, only the one shown in Figure 2, which made it difficult to understand the back of the tunic. Neither were additional images found in other publications. This is a potential problem in teaching students and professionals the Zero Waste approach in the garment manufacturing industry.

In the case of the spiral pants, three aspects showed to be necessary, which should be highlighted since they impact the results of the finished garment, such as:

1. the right and the wrong side of the fabric: when cutting and assembling one pant, according to the patternmaking diagram proposed by Holly McQuillan (Figure 1), one of the pant legs is on the right side of the fabric, other is wrong out. To avoid this problem, the pants must be cut in pairs so that the legs can be interchanged between two pants, ensuring that the fabric is straight out in all pants;

2. use of printed or textured fabric: simulations were made with the prototype with printed fabrics, which have orientation, or texture (such as velvets, for example), showed that the prints (or textures) present different directions in the resulting pieces. Figure 3 shows one of the results obtained, where the positioning and orientation of the prints on the front and back of the spiral pants can be seen. It can be observed, mainly in the backs of the pants, the diversity of orientation and direction of the simulated prints;

Figure 3 | Print orientation in spiral pants prototype (on the left, pants front view and, on the right, back view).

Source: Collection of Italiano, Kauvauti and Marcicano. Foto: Lilian S. Kauvauti, 2021.

3. variations in the fabric width and length and their influence on the size of the final garment: Given the unconventional pattern making of spiral pants, the variation in the width and length of the garment is not trivial. Thus, prototypes were developed, varying the width and length of the fabric used to understand its implications for the final size of the pieces. After several simulations, it was concluded that, for spiral pants, by fixing the width of the pattern and varying its length, the pants would change in width, producing wider or narrower pants but with the same height (Figure 4, on the left). On the other hand, by fixing the length of the pattern on the fabric and varying its width, the pants changed their height, producing longer or shorter pants, keeping the pieces the same

width (Figure 4, on the right). Likewise, the differentiated and unconventional pattern making of the spiral pants needed this type of evaluation to establish the size variations of the final garment.

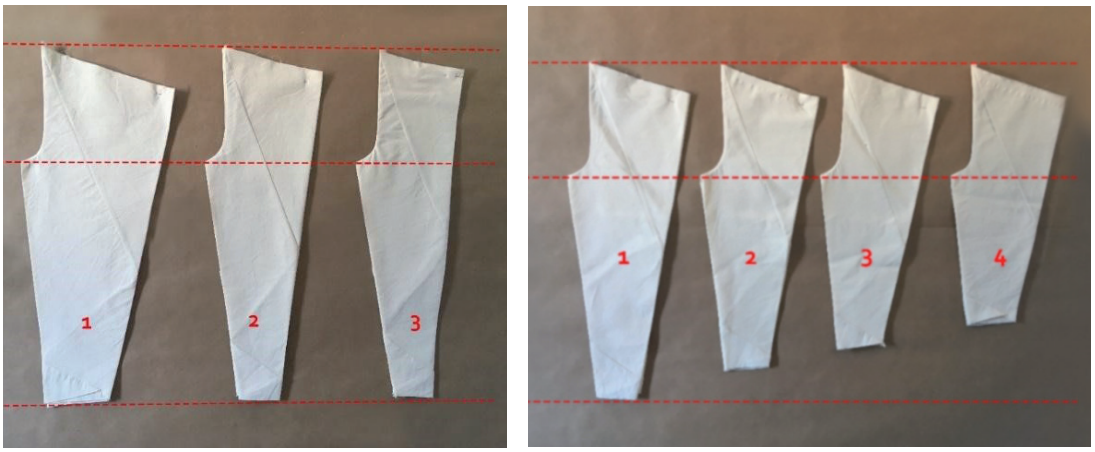

Figure 4 | Variations of the width and length of the spiral pants, design of Holly McQuillan, using the Zero Waste approach.

Source: Collection of Italiano, Kauvauti and Marcicano. Foto: Lilian S. Kauvauti, 2021.

The aspects pointed out from the development and analysis of the prototypes show that the construction of the garments in the Zero Waste approach does not follow the principles of conventional garment production and, for each garment, additional analysis are necessary to evaluate the result of each garment impacting the large-scale production process.

Thus, as a result of the bibliographic research and prototype development, it is presented the list of limiting aspects, although quite interconnected, was grouped for greater clarity:

A. ASPECTS RELATED TO DESIGN AND PATTERN MAKING WITH THE ZERO WASTE APPROACH:

A.1 - Difficulty reproducing garments developed by other designers;

A.2 - Difficulty in creating new garments with this approach;

A.3 - Difficulty in training professionals;

B. ASPECTS RELATED TO THE RAW MATERIAL USED IN THE PRODUCTION OF GARMENTS WITH ZERO WASTE APPROACH:

B.1 - Dimensions of the fabric used;

B.2 - Surface design as printis, textures, and their orientation;

C. ASPECTS RELATED TO THE SCALE OF PRODUCTION OF GARMENTS WITH A ZERO WASTE APPROACH:

C.1 - Grading and marker-making process;

C.2 - Changes in the paradigm of the production process in the clothing industry.

The discussion about the listed factors started with a set of premises. The first is related to the total use of the fabric, that is, zero waste (100% utilisation) or minimum waste in the cases where zero waste is not possible. The second premise establishes that the analysis is carried out to produce large-scale garments, either in the reproduction of a garment already created by a designer or in the creation of new garments developed by the creative team of the clothing companies.

A. Aspects related to design, reproduction, and pattern making of garments using the Zero Waste approach: *In the experiments were identified several difficulties. In addition, creating new garments, starting from the Zero Waste approach, is not trivial.*

A-1. Difficulty reproducing garments developed by other designers

- The garments made with Zero Waste pattern making, published in academic publications or virtual media, do not have instructions, measurements, or markings which facilitate their reproduction. The book by designers Timo Rissanen and Holly McQuillan, Zero Waste Fashion Design (RISSANEN; MCQUILLAN, 2016), is the only publication until the conclusion of this work. Some instructions (steps) for garments built within the Zero Waste patternmaking approach. The instructions are quite restricted, and many decisions were made based on the researcher's interpretations during the reproduction of the garments. Some of the difficulties encountered were:

- Incomplete execution instructions, with no instructions for certain elements of the garment;

- Diagram marks that are not included in the instructions;

- Absence of complete views of the garment (front, back, and side views);

- Absence of measurements (in the patterns presented by the designer) to define the size of the fabric needed to start the reproduction of the garment;

- Lack of information on how the dimensions of the fabric used (width x length) would affect the dimensions of the final product and;

- Absence of information about restrictions on the type of fabric to be used (textures and prints).

These gaps in the instructions led to interpretations during the process. Although the garments seemed, at first, simple in execution, they presented complex construction due to the absence of some instructions and detailed images. An important factor was that designer McQuillan used a piece of fabric 1.20 m wide by 1.50 m long. However, the width of 1.20 m is not standard in Brazil, which would cause a loss of material if a Brazilian-made fabric were used. Thus, it was decided the use fabric with the Brazil standard width. Other publications also do not present clear instructions that allow the reproduction of the pieces conceived by the designers. Again, in these cases, the process used must be assumed, which is often not possible, given the complexity of the garment. The lack of instruction difficulties understanding the approach and the education and training of students and professionals in the Zero Waste pattern making.

A-2. Difficulty in new designs development with the approach

In Zero Waste pattern making, new garment models can seem simple when presented in geometric diagrams or markers already developed. However, creating and developing new garments are also a challenge for designers. An important aspect to be highlighted in items c and g is that these designers must have good patternmaking training and experience. The creative process is directly linked to the patternmaking of the garment, and these two aspects are inseparable.

Another important aspect is that some applied approaches, as seen in the work of several designers, result in conceptual garments with unusual and unconventional volumes, characteristics common in Zero Waste pattern making. This method reflects its viability in the garment industry, considering commercial aspects and public acceptance. The Zero Waste approach often seeks the development of innovative pieces, which may be restricted to a specific audience.

Aakko and Niinimäki (2013, p. 73) report that the practice of Zero Waste pattern making to the full use of fabrics can limit the aesthetics of the final product, as the designs of the garment pieces share the same cut lines of the fabric. Thus, this approach becomes more challenging in carrying out a project, as it presents some unpredictability in the results.

A-3. Difficulty in training or changing the paradigm of professionals

It was noticed the importance of the designer formation with the knowledge to integrate the various sectors of production, such as pattern making, marking, cutting, and assembly, not restricted only to the aspects of creation. Rissanen and McQuillan (2016) emphasise that the steps traditionally performed separately (design, pattern making, marker, cut, etc.) must be performed together, using the Zero Waste approach. Another important aspect is that the practice of Zero Waste pattern making is not restricted only to the challenges faced with the limitations about creativity in the product's design. It also requires resources mainly, time available, for this practice to succeed. Therefore, resources such as computerised systems can help execute this work, reducing the time required.

B. Aspects related to the raw material used in garments production with Zero Waste approach:

B-1. Dimensions of the fabric used

The fabric dimensions can be considered a limiting factor in product development and the zero waste patternmaking production process. The designer Lela Jacobs mentions that in the practice of minimal or zero waste, the designer is "inherently restricted by cloth width, drape, weft, and warp, and bias" (RISSANEN; MCQUILLAN, 2016, p. 157). Thus, the designer needs to take risks and experiment because when designing garments with no waste, there is not possible to know the drape until the garment is done.

It can be said that the width of the fabric used can limit the width and length of the garments made in each design. It also depends on the position of the risk and cut (weft/warp), as was the case of the spiral pants, which used the entire width of raw cotton fabric (1.50 m), from selvage to selvage. As a result, the pants produced fit specific body sizes. An additional analysis was necessary to obtain pants with different sizes since it was not initially clear how the variation in width and length of the fabric used would influence the size of the final product. The different variations between fabric length and width resulted in narrower or shorter pants, depending on the modified parameter (width and/or fabric length), which led to questioning the full use of the fabric.

Thus, the dimensions of the raw material restrict the variety of sizes for the same model (in terms of fittings and grading of sizes for the industry) and limit the space available to design models. As a result, different approaches to fully use the fabric can be applied to large-scale production. However, the question of fidelity to the model created may change or be impossible to reproduce in certain sizes.

B-2. Adequacy of print design

The fabric's physical and visual characteristics (textures, fibre direction, prints) affected its use in the Zero Waste patternmaking approach. The direction of the cut may not follow the direction of the warp, as is conventionally done in the pattern making, fittings, and cuts of the traditional garments. Projects

with a geometric approach that use the dimension of the fabric as a whole and markers with more than one model, which also seek full use, become more challenging in their execution. These projects require greater observation of the position of pattern pairs, neckline positions, and front and back pieces when cut in fabrics with specific physical characteristics, such as prints, textures, and fibre direction.

For example, the Spiral Trousers prototype presented restrictions regarding the type of fabric used (prints and textures). Some options evaluated showed the prints were on the inside of the pants or positioned laterally or upside down.

Thus, aspects related to surface design for Zero Waste pattern making must be subject to previous tests, selecting the prints and/or textures that best fit the desired effects for the garments.

C. Aspects related to the large-scale production of garments with the Zero Waste approach:

C-1. Process of sizing (grading) and marker making

According to a measurement chart, the garment sizing (pattern grading) process used in the garment industry to produce large-scale garments increases and decreases the size of the original pattern. This process becomes a significant challenge in Zero Waste pattern making since the production of other sizes may not be obtained as directly as in the traditional approach, requiring additional analysis to assess aspects of their grading to other sizes.

Some of the Zero Waste patternmaking approaches that use conventional block patterns in their construction (e.g., the sleeveless trapeze tunic) result in a looser garment that can accommodate bodies of different sizes. However, they do not exhibit the same aesthetic and/or fit for all sizes, meaning that the garment shape, silhouette, and fit proposal may not be repeated in different sizes. Therefore, although the same model wears different body sizes, it is essential to emphasise that it is not the sizing usually applied in the industry.

Thus, the developed models need to be studied, each in its specific approach, and experimented with in its grading possibilities, which may require a particular grading process, such as the Spiral Trouser. Finally, it is worth remembering that, even with graduation, the principle of full use of fabric must be respected.

Rissanen and McQuillan (2016) suggest leaving areas of fabric that can be used flexibly according to different sizes.

All these issues were evident during the development of the spiral pants prototype since the result, in terms of dimensions, is not predictable, and variations in the dimensions of the fabric greatly alter the final garment. The possibilities of producing other garment sizes could only be estimated from the tests carried out with different widths and lengths of fabrics.

Rissanen and McQuillan (2016) list some possible paths to resolve the issue of different sizes in Zero Waste pattern making and their respective markers on the fabric. They proposed five alternatives that can be evaluated for each type of garment. The designers' proposals are reproduced below with observations and comments made by the authors of this work.

1. One-size-fits-most: "The need for grading can be eliminated by designing a garment that will fit individuals across a range of sizes" however, "this approach is mainly limited to loose, adjustable, or wrapped garments" (RISSANEN; MCQUILLAN, 2016, p.160). It is important to point out that a single size used by different bodies can change the garment's aesthetic aspects, such as fit, shape, and silhouette. When the Zero Waste model was created, the fullness planned for the garment in the original body size may not be the desired for other sizes. In addition, the limitation of the width

of the fabric can also limit the maximum size of the garment to be constructed, preventing certain garments from being produced in larger sizes.

2. Conventional grading: professionals' familiarity with the conventional grading process is a beneficial factor for its quick execution. Even if the original size of the marker is Zero Waste, the following sizes can create fabric waste (RISSANEN; MCQUILLAN, 2016). Even after each component has been graded, it is improbable that they will set up within the marker like the original size as the one designed in Zero Waste, and an important question: "Can a claim of zero waste be made of a garment if only is the sample size zero waste"? (RISSANEN; MCQUILLAN, 2016, p. 160). We understand that the answer to this question is negative. The grading and marker processes for conventional and Zero Waste patternmaking have the same limiting factor: the fabric's width. Thus, each generated size will need a different marker. With more geometric shapes, patterns built-in for Zero Waste would be easily solved in a conventional marker, with the option of dividing the marker or adding cuts; this process is possible and applicable in the industry.

3. Designing each size: different sizes can be remodelled using the original as a guide. Thus, it should ensure that each size is zero waste and is designed as similarly as possible to the original sample (RISSANEN; MCQUILLAN, 2016). However, the process can be time-consuming. Still, it fits in the context of sustainability, which emphasises "design less and design better" and that this difference is "in no way product compromised" (RISSANEN; MCQUILLAN, 2016, p.161). Thus, the designer needs to determine the components that will be graded and the grade values.

   From this first stage of the study of the components to be graded, two options occur: changing or retaining the design of the garment pieces in the marker (RISSANEN; MCQUILLAN, 2016).

   a. Changing the marker configuration: after grading the components to a specific size, a new marker is made to fit all the components, using 100% of the fabric. Keeping the original marker as possible would better assist design integrity (RISSANEN; MCQUILLAN, 2016). It is understood that this alternative is viable in terms of application, but this may not always be possible (marker making using 100% of the fabric) - it may be necessary to change some details of the original risk, adding cuttings, for example.

   b. Retaining the marker configuration: in this case, the first alternative is to change the total fullness of the garment, if possible. Pleats, tucks, darts, and gathers can be employed to control fullness through sizes. For example, in a dress with several vertical pleats across the body, a larger size will have fewer pleats than a smaller one; the different sizes contain the same total amount of fabric. The second alternative is mixing two sizes in a marker. For example, in a marker with two garments of the original size (Medium), a P and a G piece could be cut, compensating for the spaces between them. However, it must be considered that both alternatives (maintaining the marker and changing the marker) may have limitations when applied to certain garments, not to a general case (RISSANEN; MCQUILLAN, 2016).

4. Using a different fabric width for each size: an alternative would be the use of fabrics with different widths for different sizes, mentioning, as an example, tubular knit fabrics, knitted in a range of diameters to create a range of sizes (RISSANEN; MCQUILLAN, 2016).

   We understand that flat fabrics in the Brazilian market are manufactured with similar widths (1.40 m or 1.50 m), with few exceptions. Thus, this alternative, proposed by Rissanen and McQuillan (2016), appears to apply only to cases of knitted pieces.

5. A hybrid method: combining the previous four pathways (RISSANEN; MCQUILLAN, 2016).

Many solutions exist for grading, given the variability of garments, the changing size range requests of a company, and variants in grade rules. The suitable solution is based on the garment type, style, size range, fabric type, and width (RISSANEN; MCQUILLAN, 2016).

C-2. Change in the paradigm of the production process in clothing

> The Zero Waste patternmaking approach requires an integrated view of the product development process. McQuillan (2011) mentions that the current design process follows a separate hierarchy of design, creation, and pattern making, that it results in textile waste, and that there is little risk or little creativity in the fast process of today's fashion, being easier to be inspired by models with sales guarantee to take risks in creating something new. The zero-waste fashion design could help renovate the hierarchies that exist in the fashion structure, with possible constructive implications for both design and manufacturing, since the traditionally separate roles of design: pattern making, grading, marker making, and sewing are all indispensable components of fashion design (RISSANEN; MCQUILLAN, 2016, p. 153). Thus, "With manufacturing, the scope of design expands to grading and marker making" (RISSANEN; MCQUILLAN, 2016, p. 153). This does not mean eliminating one or more process functions but improving communication and integration.

Many of the limitations discussed may limit or prevent using the Zero Waste approach in apparel production. However, it can also be seen that there are alternatives to overcome the limitations presented if the company seeks the Zero Waste approach as an alternative to producing clothing; several of them are discussed here. Although the alternatives discussed here are challenging in their implementation, such as using additional resources in terms of time and materials, they prove viable.

In the course of the study and development of the prototypes, we notice the need for an integrated view of the entire design process, extending it to the more technical aspects of pattern making and marker making, requiring an essential change in the current paradigm of clothing production. This change in the industrial environment can become a difficult barrier to overcome. In addition, the issue of additional time, both to develop something new and to replicate something already existing in the Zero Waste patternmaking approach, is an important point that must also be considered. Many companies may not be interested in the zero-waste approach because, in many cases, the clothes produced with this approach are restricted to certain consumer profiles.

5 CONCLUSIONS

The study of the Zero Waste patternmaking approach is still present, mainly in the experimental scope. However, academic works and experiences have shown at events emphasising the challenge of the Zero Waste approach in clothing.

The designer McQuillan has researched the industry, teaching the Zero Waste patternmaking approach through workshops. One of the companies involved in the study said that the cost of the fabric did not compensate for the additional costs to obtain more efficient markers, although the result was satisfactory. At the end of the workshop, the designer reports: "The overall experience for myself in this project was of a forced arbitration between 'what exists' and 'what can be' – where 'what exists' won due to the massive force the scale and complexity of the industry exert on those who seek to change it" (MCQUILLAN, 2019, p. 157). However, certain technological resources can contribute to Zero Waste design being implemented in industries, such as the use of 3D modelling software, for example (MCQUILLAN, 2020).

A strong issue to be considered is the full use of the fabric (due to the marker making for cutting) of the Zero Waste pattern making compared to an equivalent conventional pattern making. Few discussions analyse the efficiency of this part of the process. Thus, an analysis of material consumption is considered

important for each model elaborated so that it can be affirmed that the Zero Waste pattern making is, in fact, more economical and maybe more attractive despite the need for more time and resources spent to create a fashion collection. It can be said that the application of Zero Waste pattern making in large-scale production is conditioned to all the limiting factors mentioned in this work, which makes its execution even more complex. It is challenging to establish the resources necessary to produce garments with the Zero Waste approach considering each project is unique, with specificities in pattern making, marker making, size grading, and type of fabric. In addition, it still requires changes in the communication and performance of the professionals involved in the process. To deal with these limiting factors, it is important to question the benefit of garment manufacturing companies in using the Zero Waste approach in their production process, even if additional resources are needed.

The comparison of conventional and Zero Waste patternmaking practices showed divergent paths. While conventional modelling can be "safe and controlled" within the current hierarchy, Zero Waste modelling can be characterised as "uncertain and challenging", requiring changes in clothing production.

From the reflections on the application of Zero Waste in pattern making discussed in this article, important aspects were not addressed and should be considered as possible future works: 1) research applied to companies – for a better analysis of feasibility and acceptance; 2) analysis of the consumption of models/fittings of other garments, to identify, in general, aspects related to the consumption of garments in the Zero Waste approach; and 3) elaboration of step-by-step analysis and scripts for other garments developed by authors in the area, aiming at teaching, professional training, and production activities.

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Zero waste na indústria do vestuário: limitações e alternativas

Zero waste in the apparel industry: limitations and alternatives

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RESUMO

A abordagem *Zero Waste* (ou zero resíduo), aplicada à produção do vestuário, promete a eliminação dos descartes têxteis durante o processo produtivo, promovendo ações em direção à sustentabilidade. Dentro dessa perspectiva, o presente artigo contribui para que empresas de confecção têxtil possam aplicar processos mais sustentáveis, visando à eliminação dos resíduos. Para tanto, como principal objetivo, o trabalho busca identificar aspectos críticos e limitações do processo de criação e modelagem usando a abordagem *Zero Waste* para sua aplicação na indústria do vestuário, na produção em larga escala. Para isso, a pesquisa partiu de bibliografia relacionada ao tema e da identificação e análise das propostas dos principais designers do vestuário que utilizam as técnicas de criação e modelagem com a abordagem *Zero Waste*. Como resultado, o artigo apresenta uma discussão sobre os principais aspectos limitantes e alternativas viáveis para sua implementação no processo produtivo de confecção de vestuário em larga escala.

Palavras-chave: Zero resíduo. Vestuário. Indústria. Sustentabilidade têxtil.

ABSTRACT

The Zero Waste approach applied to garment manufacturing promises the elimination of textile waste in the production process, making the process more sustainable. This article contributes to aiding textile manufacturing companies in applying more sustainable techniques to reduce waste. Therefore, the main objective is to identify critical aspects and limitations of the design and the patternmaking process

using the Zero Waste approach to apply in the garment industry in large-scale production. The study initiates with zero waste bibliography research and identification and analysis of the proposals of the fashion designers who use the Zero Waste approach to garment design and pattern making. As a result, the article presents critical aspects and limitations of the approach and discusses viable alternatives for its implementation in the large-scale garment manufacturing process.

Keywords: Zero waste. Apparel. Industry. Textile sustainability.

1 INTRODUÇÃO

O conceito de desenvolvimento sustentável não é novo e pode ser definido de várias formas. Uma definição famosa e apropriada foi dada pela World Commission on Environment and Development em 1987, em que desenvolvimento sustentável significa o desenvolvimento que atenda às necessidades do presente sem comprometer o atendimento das necessidades das gerações futuras (MUTHU *et al.*, 2012).

No campo da sustentabilidade ambiental, estudos de economistas e ambientalistas recomendam que seja evitada a geração de resíduos nas fases de fabricação ou no descarte dos produtos após o uso (CUC; VIDOVIC, 2011). No entanto, a indústria têxtil gera cerca de 15% de resíduos do que produz entre o corte e a produção de roupas, sendo que da produção total de têxtil mundial, no ano de 2015, que foi cerca de 400 bilhões de metros quadrados, considerando-se a estimativa de geração de resíduo de 15%, estima-se que foram gerados cerca de 60 bilhões de metros quadrados em resíduos (RISSANEN; MCQUILLAN, 2016).

A criação da Lei nº 12.305, de 2010, que dispõe sobre a Política Nacional de Resíduos Sólidos (PNRS), levou as indústrias de confecção do vestuário a buscarem alternativas para a gestão adequada e responsável do resíduo têxtil. São vários os pontos de atenção, dentro das etapas e dos recursos utilizados e produzidos pela indústria têxtil e de confecção, que podem ser alvo de melhorias, como o uso de fibras renováveis e biodegradáveis, alternativas de reciclagem, baixo uso de substâncias químicas nas culturas dos materiais têxteis, baixo uso de energia e de água, entre outros fatores (FLETCHER; GROSE, 2011). Ainda conforme os mesmos autores, são necessárias mudanças no *design* das roupas, de modo a diminuir ou eliminar resíduos e oferecer ao mercado peças com conceitos atemporais, com maior durabilidade e vida útil. Além disso, cabe também ao consumidor uma parcela de responsabilidade, buscando um consumo mais inteligente e que minimize o descarte para apoiar as iniciativas rumo à indústria sustentável.

Assim, os *designers* são agentes importantes na busca da moda mais sustentável, com alternativas inovadoras em peças com estilo, qualidade e durabilidade, que minimizem ou eliminem os resíduos a partir do momento da concepção da peça até as etapas de sua confecção. Uma das abordagens que buscam a eliminação total do resíduo na concepção e construção de peças do vestuário é a abordagem *Zero Waste* que atua diretamente na fonte de geração de resíduos, podendo se enquadrar na perspectiva das tecnologias limpas, cujos processos produtivos são modificados considerando a preocupação ambiental (PEREZ; CAVALCANTE, 2014).

Vários *designers* de moda vêm utilizando a abordagem *Zero Waste*, em que o processo criativo passa a ser executado em conjunto com as etapas de modelagem e de encaixe dos moldes para o corte no tecido. Vale lembrar que, no processo de criação de moda convencional, essas etapas são realizadas de forma independente entre si e, normalmente, por profissionais com diferentes especialidades, sendo que o esboço (ou croqui) é a forma geralmente utilizada para criação.

A partir do esboço são estabelecidos os detalhes, as cores, os aspectos estéticos, entre outros. Porém, nesse momento, não se pode ainda identificar e calcular o desperdício, pois só é possível ocorrer nas etapas seguintes quando são realizadas as modelagens e o corte. Em contrapartida a esses padrões hierárquicos das etapas do processo convencional, a prática de criação de moda *Zero Waste* atua de forma dinâmica em seus processos, cujas etapas tradicionalmente executadas de forma separada são, necessariamente, realizadas em conjunto.

Assim, a etapa de modelagem se torna parte integral do processo e contribui ativamente para a geração de ideias. Tal mudança de padrões realça a necessidade do *designer* em estar aberto às possibilidades e aceitar os riscos e os desafios dessa prática (RISSANEN; MCQUILLAN, 2016, p. 123).

No entanto, apesar das inúmeras propostas de criação e modelagem *Zero Waste* já apresentadas por diversos *designers*, várias questões surgem ao se avaliar sua aplicação no processo de produção em larga escala. Ao se estudar, com detalhes, o trabalho desses *designers*, percebe-se que o tempo necessário para o processo de criação se amplia, além da sua complexidade.

Por se tratar de técnicas não convencionais e desconhecidas pela maioria dos profissionais da indústria de confecção têxtil, a aplicação dos conceitos da abordagem *Zero Waste*, tanto na etapa de criação quanto nas posteriores, requer diversos ajustes no processo produtivo. A principal questão, e talvez a mais discutida, está relacionada à etapa de graduação dos moldes. É nessa etapa que os moldes, produzidos em um tamanho base, são ampliados ou reduzidos para atender à grade de tamanhos oferecida pela empresa. Ocorre que, em geral, um primeiro tamanho (tamanho base) é produzido com os conceitos da abordagem *Zero Waste* e na graduação nem sempre é simples ou possível de manter todos os tamanhos da grade com o mesmo conceito. A graduação de moldes, porém, não é a única questão a ser resolvida pelas empresas de confecção do vestuário que optam pela aplicação dessa abordagem, pois outros fatores limitantes existem ao se pensar em sua aplicação em larga escala.

Recentemente, outros pesquisadores se voltaram para a graduação de moldes. ElShishtawy *et al.* (2021) realizaram uma revisão bibliográfica sistemática sobre os temas de pesquisa operacional de corte e encaixe e o *design* de vestuário *Zero Waste*. Como resultado, os autores reforçam a integração dos processos nesta abordagem, diferentemente do processo convencional, indicando que as pesquisas futuras devem tentar incorporar os algorítmos de corte e encaixe nos processos de *design Zero Waste*.

Para otimizar o processo produtivo, buscando alcançar zero resíduo, Ramkalaon e Sayem (2021) investigaram a aplicação do conceito de corte de moldes *Zero Waste* na produção em larga escala. Os autores desenvolveram um *framework* para implementar o conceito em diferentes grades de tamanho. O *framework* foi testado em dois tipos de roupas em diferentes tamanhos. Foram utilizadas ferramentas digitais para o corte e desenho dos moldes, e protótipos físicos foram confeccionados para experimentar o ajuste das roupas. Como resultado, os autores conseguiram alcançar 98% de rendimento do tecido, sendo que 85% já são considerados impossíveis. Carrico *et al.* (2022) investigaram a eficácia da técnica *Carrico Zero Waste Banded grading* na produção em escala de vestuário com grades de tamanho. A técnica foi ensinada para seis *designers* que a aplicaram na produção em escala. De acordo com os autores, a técnica foi eficaz na redução das sobras de tecido.

Considerando as pesquisas recentes sobre o tema, percebe-se a relevância de alguns aspectos limitantes que podem prejudicar a implementação da abordagem *Zero Waste* em larga escala, nas indústrias, como a graduação de moldes, o encaixe e corte das peças e a busca por soluções que minimizem essas questões. No entanto, os trabalhos citados se restringem a determinados problemas, ainda que importantes, mas não abordam o processo completo, isto é, as questões que permeiam a abordagem *Zero Waste* desde o processo criativo até os aspectos operacionais.

Assim, propõe-se, no presente trabalho, identificar os principais aspectos críticos ou limitantes da aplicação da abordagem de criação e modelagem de peças com a abordagem sem resíduo (*Zero Waste*), para sua aplicação na indústria do vestuário, além de buscar e apresentar alternativas para superar essas limitações, ainda que parcialmente. Entende-se que a relevância do trabalho está em oferecer às empresas de confecção têxtil alternativas para a produção de moda mais sustentável, por meio da modelagem e criação *Zero Waste*.

2 A ABORDAGEM ZERO WASTE APLICADA À CONCEPÇÃO E À CONFECÇÃO DO VESTUÁRIO

Segundo Rissanen e McQuillan (2016), o termo *Zero Waste* surge no campo da moda por volta de 2008, como um novo fenômeno. Entretanto, os mesmos autores afirmam que Paul Palmer, fundador do *Zero Waste* Institute em 1970 e que desde então publicou muitas críticas sobre o desperdício na indústria moderna, está entre os primeiros a utilizar esse termo.

Vale ressaltar que o *Zero Waste* é um termo novo, mas a sua prática é tão antiga quanto "vestir o corpo com pele ou roupa" (RISSANEN; MCQUILLAN, 2016, p. 11, tradução nossa).

Na Antiguidade, era comum a tecelagem em teares cujas dimensões eram reduzidas, assim "não se tecia uma peça inteira que pudesse em seguida ser cortada à vontade, mas, sim, uma série de peças reduzidas que eram unidas por costuras" e, em outro momento, tecidos retangulares que não sofriam nenhuma transformação e eram enrolados em torno do corpo de diversas maneiras (BOUCHER, 2012, p. 24). Nos períodos históricos posteriores, muitas são as peças do vestuário cuja concepção parte do aproveitamento total do tecido, sem produção de resíduos.

Após a Revolução Industrial, com tecidos mais baratos, essa prática foi deixada de lado. A moda começou a cumprir novas estéticas que não puderam ser interligadas à produção sem resíduos. Contudo, o pensamento do desperdício zero começa a reaparecer no século XX (YIELD EXHIBITION, 2011) e passa a ser questionado com mais intensidade a partir da segunda metade do século, com o surgimento do conceito de sustentabilidade, após a Conferência de Estocolmo, na Suécia, em 1972 (BERLIM, 2012). A partir de então, surgem os pioneiros contemporâneos do desperdício zero, e Firmo (2017) apresenta a inglesa Zandra Rhodes, que, na década de 1970, traz a confecção de vestuário usando a abordagem *Zero Waste*. Nesse período, Rhodes trabalhava com cortes geométricos em suas criações, resultando em peças que envolviam o corpo sem nenhum tipo de costura.

Aakko e Niinimäki (2013) explicam que o método de zero resíduo entra na moda com o particular objetivo de eliminar o desperdício de tecidos na produção de vestuário já no momento da criação do desenho e afirmam que, para essa abordagem, é imprescindível que exista a integração da modelagem com o processo de desenho, em contraste à prática convencional da modelagem seguida da criação predeterminada do produto. Rizzi, Anicet e Meurer (2017) enfatizam que o *designer* deve conceber um produto já pensando em uma modelagem que seja capaz de não gerar resíduo e, caso algum resíduo seja produzido, que seja aproveitado na própria peça. Assim, a modelagem integrada à criação do produto é o que diferencia o processo do projeto de moda *Zero Waste* do processo convencional.

Diversos são os *designers* que trabalham a criação e modelagem integradas, dentro da abordagem *Zero Waste*. Alguns nomes já foram citados, como Holly McQuillan e Timo Rissanem. No entanto, profissionais como Yeohlee Teng, Julien Roberts, David Telfer, Caroline Briebe, Carla Fernández, Tara St. James, Mark Liu e vários outros têm desenvolvido experimentos utilizando a abordagem *Zero Waste* (LIU, 2017; MCQUILLAN, 2011; RISSANEN; MCQUILLAN, 2016; ROBERTS, 2013; TENG, 2018; YIELD EXHIBITION, 2011). Esses *designers* buscam a criação de peças inovadoras e propõem diferentes técnicas para alcançar seus objetivos. Entre os *designers* citados, apenas Rissanen e McQuillan foram além dos processos criativos e buscaram sistematizar os conceitos e as práticas da abordagem *Zero Waste* no vestuário, discutindo aspectos críticos ou limitantes para sua aplicação na indústria, em larga escala.

3 MATERIAIS E MÉTODO

A pesquisa desenvolvida adota o modelo qualitativo, baseado na observação e análises associativas de dados, sendo a modalidade de estudo, de reconhecimento, um subgrupo do método qualitativo. A

delimitação da zona de interesse da pesquisa fica na interseção dos conceitos do *design* de moda com os conceitos de sustentabilidade, ou seja, o trabalho se insere na perspectiva sustentável do processo de criação e de modelagem do vestuário.

A parte principal da pesquisa foi baseada em material bibliográfico, nos aspectos referentes à sustentabilidade, ao fenômeno da modelagem *Zero Waste* e à relação desses conceitos com o *design* de moda. A partir dessa busca, pode-se identificar como *designers* destacados no mercado aplicam as técnicas de modelagem *Zero Waste*, o que permitiu estabelecer boa parte das limitações dessa abordagem.

Indo mais além, optou-se por desenvolver protótipos de algumas peças de vestuário, reproduzindo o processo proposto por *designers*, seguindo suas instruções (quando presentes). Foram escolhidas duas peças elaboradas por Holly McQuillan e Timo Rissanen, principais *designers* na abordagem *Zero Waste*. Apesar de não estar detalhado no presente artigo, o desenvolvimento desses protótipos permitiu identificar aspectos limitantes adicionais do processo de modelagem e criação *Zero Waste*. Os protótipos foram desenvolvidos utilizando-se manequins de moulage (modelagem tridimensional) em tamanho natural (40), em tamanho reduzido (50% de redução, tamanho 40) e tecido algodão cru, de gramatura média. Foram feitos registros fotográficos e escritos sobre os protótipos reproduzidos, o que possibilitou fazer uma análise crítica das abordagens experimentadas.

4 RESULTADOS E DISCUSSÃO

A pesquisa bibliográfica possibilitou a identificação dos principais aspectos críticos e limitantes que devem ser observados ao se pensar na aplicação da abordagem *Zero Waste* na produção industrial do vestuário, desde o processo criativo (associado à modelagem e encaixe dos moldes) até suas etapas produtivas. Porém, experimentar as técnicas propostas pelos *designers* do *Zero Waste* foi de especial importância para se apreender a complexidade do processo de modelagem de peças não convencionais, utilizando um processo integrado de criação e modelagem.

Durante a elaboração dos protótipos, seguindo os processos criativos propostos pelos *designers*, aspectos relevantes emergiram, que não haviam sido encontrados na pesquisa bibliográfica. Foram escolhidas duas peças elaboradas pela *designer* McQuillan, apresentadas em Rissanen e McQuillan (2016): a “túnica trapézio sem mangas” (Figura 2) e a “calça espiral” (Figura 1).

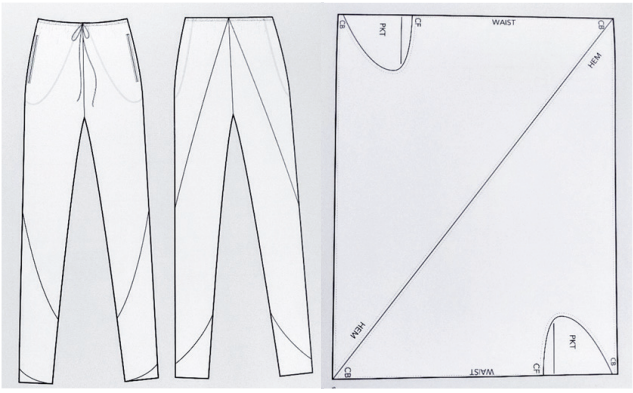

Figura 1 | Desenho técnico e modelagem da calça em espiral, criação de Holly McQuillan, usando a abordagem *Zero Waste*.

Fonte: Rissanen e McQuillan (2016, p. 115).

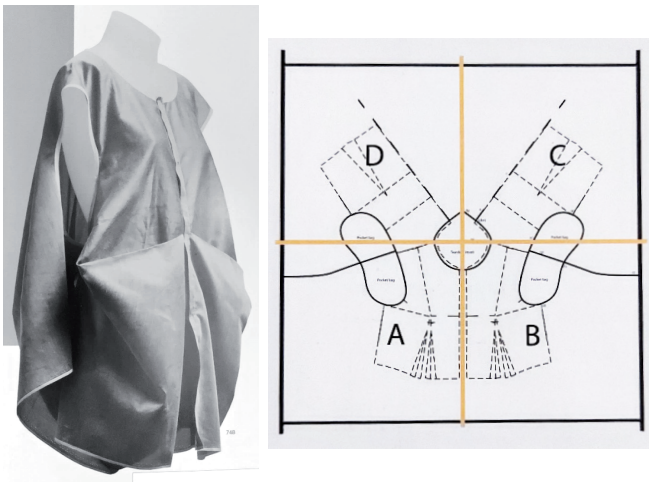

Figura 2 | Túnica trapézio e sua modelagem, criação de Holly McQuillan, usando a abordagem *Zero Waste*.

Fonte: Rissanen e McQuillan (2016, p. 97-96).

Os dois protótipos fazem aproveitamento total do tecido, utilizando toda sua largura. Apesar de modelagem simples, vários desdobramentos importantes surgiram, indicando limitações da abordagem para sua aplicação na produção de vestuário em larga escala.

O primeiro aspecto observado, em ambos os protótipos, foi a pequena quantidade de instruções disponíveis em relação ao processo de desenvolvimento das peças. São várias etapas para a elaboração de cada uma das peças e, no entanto, muitos detalhes estão ausentes nas instruções ou mostram explicações dúbias, sendo que o processo de reprodução requereu várias tentativas, até que se pudesse compreender e replicar as peças corretamente. No caso da túnica trapézio, a publicação utilizada como base não apresenta nenhuma outra imagem da peça, apenas aquela mostrada na Figura 2, o que dificultou a interpretação da parte das costas da túnica. Tampouco foram encontradas imagens adicionais em outras publicações. Esse é um aspecto importante, uma vez que existe a necessidade de se formar estudantes e profissionais com conhecimento na abordagem *Zero Waste*, para alavancar sua aplicação nas indústrias de confecção têxtil.

Sobre a calça espiral, três aspectos se mostraram importantes, que devem ser destacados, uma vez que impactam os resultados da peça finalizada, a saber:

1. Direito e avesso do tecido: ao se cortar e montar uma única calça, conforme o diagrama de modelagem proposto por Holly McQuillan (Figura 1), uma das pernas da calça fica com o direito do tecido para fora e a outra fica com o avesso para fora. Para que isso não ocorra, as calças devem ser cortadas em pares, de modo que se possa intercambiar as pernas entre duas calças, garantindo que o direito do tecido fique para fora em todas as peças.

2. Uso de tecido estampado ou com textura: simulações do protótipo com tecidos estampados, que tenham orientação, ou com textura (como veludos, por exemplo), mostraram que as estampas (ou texturas) apresentam orientação diversa nas peças resultante. A Figura 3 mostra um dos resultados obtidos, em que se pode ver o posicionamento e a orientação das estampas no dianteiro e no traseiro da calça espiral. Pode-se notar, principalmente nos traseiros das calças, a diversidade de orientação e sentido das estampas simuladas.

Figure 3 | Orientação das estampas em protótipos da calça espiral (à esquerda, visão dianteira das calças e, à direita, visão traseira).

Fonte: Acervo de Italiano, Kauvauti e Marcicano. Foto: Lilian S. Kauvauti, 2021.

3. Variações na largura e no comprimento do tecido e sua influência no tamanho da peça final: dada a modelagem não convencional da calça espiral, a variação na largura e comprimento da peça não é trivial. Assim, foram desenvolvidos protótipos variando largura e comprimento do tecido utilizado para se entender suas implicações no tamanho final das peças. Após várias simulações, chegou-se à conclusão que, para a calça espiral, fixando-se a largura do molde e variando seu comprimento, as calças se modificavam na largura, produzindo calças mais largas ou mais estreitas, porém, com a mesma altura (Figura 4, à esquerda). Ao se fixar o comprimento do molde no tecido e variar sua largura, as calças modificavam suas alturas, produzindo calças mais longas ou mais curtas, mantendo as peças com a mesma largura (Figura 4, à direita). Da mesma forma, a modelagem diferenciada e não convencional da calça espiral requereu esse tipo de avaliação para se estabelecer as variações de tamanho da peça final.

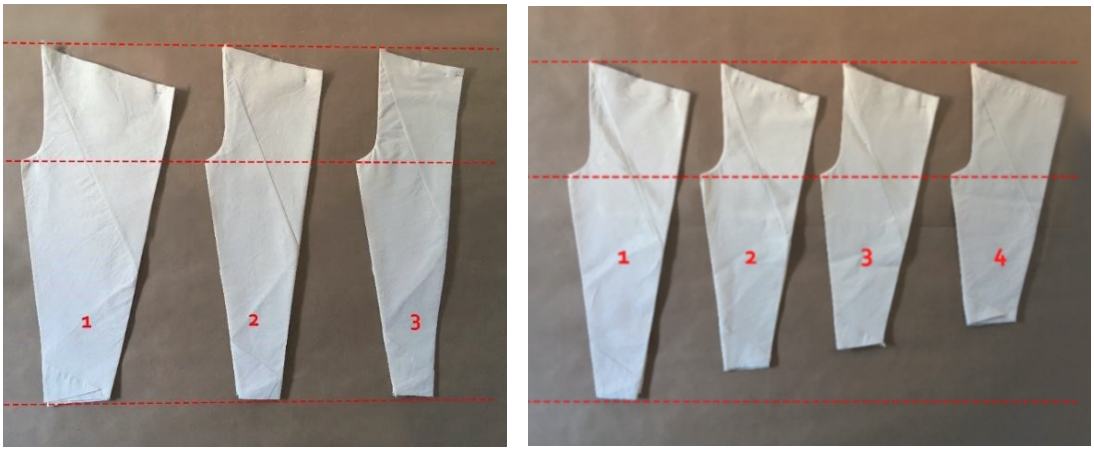

Figura 4 | Variações de largura e comprimento da calça espiral, criação de Holly McQuillan usando a abordagem *Zero Waste*.

Fonte: Acervo de Italiano, Kauvauti e Marcicano. Foto: Lilian S. Kauvauti, 2021.

Os aspectos apontados a partir da elaboração e análise dos protótipos mostram que a confecção das peças na abordagem *Zero Waste* não segue os princípios da confecção de vestuário convencional e, para cada peça, são necessárias análises adicionais para avaliar o resultado final de cada peça e se impactam o processo produtivo para a produção em larga escala.

Assim, como resultado da pesquisa (bibliográfica e execução dos protótipos), apresenta-se, a seguir, a lista dos aspectos limitantes que, apesar de bastante interligados, foram agrupados visando maior clareza:

A. ASPECTOS RELACIONADOS À CRIAÇÃO E À MODELAGEM DE PEÇAS COM ABORDAGEM ZERO WASTE:

A.1 - Dificuldade para reproduzir peças desenvolvidas por outros *designers*;

A.2 - Dificuldade na criação de novas peças com essa abordagem;

A.3 - Dificuldade na formação de profissionais;

B. ASPECTOS RELACIONADOS À PRODUÇÃO EM ESCALA DE PEÇAS COM ABORDAGEM ZERO WASTE:

B.1 - Dimensões do tecido utilizado;

B.2 - Design de superfície (estampas, texturas e sua orientação);

C. ASPECTOS RELACIONADOS À PRODUÇÃO EM ESCALA DE PEÇAS COM ABORDAGEM ZERO WASTE:

C.1 - Processo de graduação e encaixe;

C.2 - Mudança no paradigma do processo produtivo em confecções.

Para a discussão sobre os fatores elencados, partiu-se de um conjunto de premissas. A primeira está relacionada ao uso total do tecido, ou seja, busca-se perda zero (aproveitamento de 100%) ou perda mínima, nos casos em que a perda zero não é possível. A segunda premissa estabelece que a análise é feita para a produção de peças em larga escala, seja na reprodução de alguma peça já criada por um *designer* ou na criação de novas peças, concebidas pela equipe de criação das empresas de confecção do vestuário.

A. Aspectos relacionados à criação, reprodução e modelagem de peças com abordagem Zero Waste: *foram identificadas diversas dificuldades ao se tentar reproduzir peças desenvolvidas pelos designers que são referência na área. Além disso, identificou-se que a criação de novas peças, partindo da abordagem Zero Waste, não é trivial.*

A-1. Dificuldade para reproduzir peças desenvolvidas por outros designers

- As peças feitas com a modelagem *Zero Waste*, divulgadas em publicações acadêmicas ou meio virtual, não possuem instruções, nem medidas ou marcações que facilitem sua reprodução. O livro dos *designers* Timo Rissanen e Holly McQuillan, *Zero Waste Fashion Design* (RISSANEN; MCQUILLAN, 2016), é a única publicação, até o momento da conclusão do presente trabalho, em que constam algumas instruções (passos) de peças construídas dentro da abordagem de modelagem *Zero Waste*. As instruções são bastante restritas e muitas decisões, durante os processos de reprodução das peças, foram tomadas com base em inferências da pesquisadora. Algumas das dificuldades encontradas foram:

- Instruções de execução incompletas, com ausência de instruções para certos elementos da peça;

- Marcações no diagrama que não constam nas instruções;
- Ausência de imagens mostrando todas as visões da peça (frontal, traseira e lateral);
- Ausência de medidas (nos moldes apresentados pela *designer*) para definir o tamanho do tecido necessário para iniciar a reprodução da peça;
- Ausência de informações sobre como as dimensões do tecido utilizado (largura x comprimento) afetariam as dimensões do produto final e;
- Ausência de informações sobre as restrições do tipo de tecido a ser utilizado (texturas e estampas).

Essas lacunas nas instruções levaram a inferências durante o processo e, apesar das peças parecerem, a princípio, simples na execução, apresentaram construção complexa devido à ausência de instruções e imagens detalhadas. Um fator importante foi que a *designer* McQuillan propõe o uso de um pedaço de tecido com 1,20 m de largura por 1,50 m de comprimento. No entanto, a largura de 1,20 m não é padrão no Brasil, o que ocasionaria perda de material, caso fosse utilizado um tecido de fabricação brasileira. Assim, optou-se pelo uso de tecido com a largura padrão no Brasil. Outras publicações pesquisadas também não apresentam instruções claras que possibilitem a reprodução das peças concebidas pelos *designers*. Novamente, nesses casos, deve-se inferir o processo utilizado, o que muitas vezes não é possível, dada a complexidade da peça. Isso dificulta o entendimento da abordagem e a formação e treinamento de estudantes e profissionais na modelagem *Zero Waste*.

A-2. Dificuldade na criação de novas peças com essa abordagem

A criação de novos modelos de peças, na abordagem da modelagem *Zero Waste*, pode parecer simples, quando apresentados em diagramas geométricos ou encaixes de projetos já resolvidos. No entanto, a criação e desenvolvimento de novas peças é, também, um desafio para os *designers*. Um aspecto importante que será mais bem abordado nos itens c e g é que esses *designers* devem ter boa formação e experiência em modelagem, uma vez que o processo criativo está diretamente ligado à modelagem da peça, sendo esses dois aspectos indissociáveis.

Outro aspecto importante é que algumas abordagens aplicadas, como visto nos trabalhos de vários *designers*, resultam em peças conceituais, com volumes incomuns e pouco convencionais, comuns na modelagem *Zero Waste*. Isso leva a uma reflexão sobre sua viabilidade na indústria da confecção têxtil, em relação aos aspectos comerciais e relacionados à aceitação do público, uma vez que a abordagem *Zero Waste* busca o desenvolvimento de peças inovadoras, que podem ficar restritas a um público específico.

Aakko e Niinimäki (2013, p. 73) relatam que a prática da modelagem *Zero Waste*, guiada pelo aproveitamento total de tecidos, pode colocar alguns limites quanto à estética do produto final, pois os projetos das peças compartilham as mesmas linhas de corte do tecido. Assim, essa abordagem se torna mais desafiadora na realização de um projeto, por apresentar certa imprevisibilidade nos resultados.

A-3. Dificuldade na formação ou mudança de paradigma de profissionais

Percebeu-se a importância na formação do *designer* com conhecimentos que possibilitem integrar os vários setores da produção, como modelagem, risco, corte e montagem, não se restringindo apenas aos aspectos da criação. Rissanen e McQuillan (2016) destacam que as etapas tradicionalmente executadas separadamente (criação, modelagem, risco, corte, etc.) devem ser exercidas em conjunto com a abordagem *Zero Waste*. Outro aspecto importante é que a prática

da modelagem *Zero Waste* não se restringe apenas aos desafios enfrentados com as limitações em relação à criatividade no produto, mas que também exige recursos (principalmente, o tempo) disponíveis, para que essa prática seja realizada com sucesso. Assim, alguns recursos, como os sistemas computadorizados, podem auxiliar na execução do trabalho, diminuindo o tempo necessário.

B. Aspectos relacionados à matéria-prima usada na produção de peças com abordagem Zero Waste:

B-1. Dimensões do tecido utilizado

As dimensões do tecido, para a modelagem *Zero Waste*, podem ser consideradas um fator limitante nos processos do desenvolvimento do produto e da produção. Lela Jacobs, *designer*, menciona que na prática do mínimo ou zero desperdício, o *designer* fica "inerentemente restringido pela largura, caimento, trama, urdume e viés do tecido" (RISSANEN; MCQUILLAN, 2016, p. 157). Assim, o *designer* precisa arriscar e experimentar, pois, durante a criação usando *Zero Waste*, não há como prever qual será o caimento da peça, até que ela esteja construída.

Pode-se dizer que a largura máxima do tecido utilizado pode limitar a largura/comprimento das peças confeccionadas em cada projeto, dependendo da posição do risco e corte (trama/urdume), como foi o caso da calça espiral que utilizou a largura total do tecido de algodão cru (1,50 m), de ourela a ourela. A calça produzida vestiu determinado tamanho de corpo. Para se obter calças com diferentes tamanhos, foi necessária uma análise adicional, já que não estava claro, inicialmente, como a variação de largura e de comprimento do tecido utilizado influenciariam o tamanho do produto final. As diferentes variações entre comprimento do tecido e larguras resultaram em calças mais estreitas ou mais curtas, dependendo do parâmetro modificado (largura e/ou comprimento do tecido), o que levou ao questionamento sobre o aproveitamento total do tecido.

Assim, entende-se que as dimensões da matéria-prima restringem a variação de tamanhos para um mesmo modelo (em termos de encaixes e graduação de tamanhos para a indústria) e limitam o espaço disponível para a criação dos modelos. Diferentes abordagens para o aproveitamento total do tecido podem ser aplicadas, no entanto, visando à produção em escala. A questão da fidelidade ao modelo criado pode sofrer alterações ou impossibilidade de reprodução em determinados tamanhos.

B-2. Adequação do *design* de superfície

O uso do tecido, quando analisado por suas características físicas e visuais (texturas, direção das fibras, estampas), também é afetado na abordagem da modelagem *Zero Waste*. A direção do corte pode não seguir o sentido do urdume, como convencionalmente são realizados as modelagens, encaixes e cortes da confecção tradicional. Projetos com abordagem geométrica que utilizam a dimensão do tecido como um todo e encaixes com mais de um modelo, que também buscam o aproveitamento total, tornam-se mais desafiadores na sua execução, em relação aos aspectos do uso do tecido. Tais projetos requerem maior observação na posição dos pares de moldes, posições de decotes e partes frontais e traseiras, quando cortados em tecidos com características físicas específicas, como estampas, texturas e direção das fibras.

Como exemplo, o protótipo da calça espiral apresentou restrições em relação ao tipo de tecido utilizado (estampas e texturas). Em algumas das opções avaliadas, as estampas ficaram no lado interno da calça ou posicionadas lateralmente ou invertidas.

Assim, os aspectos relacionados ao *design* de superfície, para a modelagem *Zero Waste*, devem ser alvo de testes prévios, selecionando as padronagens e/ou texturas que mais se encaixam nos efeitos desejados para as peças.

C. Aspectos relacionados à produção em escala de peças com abordagem Zero Waste:

C-1. Processo de graduação e encaixe

O processo de graduação dos moldes, utilizado na indústria da confecção do vestuário, para a produção de peças em larga escala, parte de um molde em tamanho base, que deve ser ampliado ou reduzido, de acordo com a tabela de medidas. Esse processo torna-se um grande desafio na modelagem *Zero Waste*, uma vez que a produção de outros tamanhos pode não ser obtida tão diretamente quanto na abordagem tradicional, necessitando análises adicionais para avaliar os aspectos de sua graduação para outros tamanhos.

Algumas das abordagens de modelagem *Zero Waste* que utilizam blocos de moldes convencionais na sua construção (por exemplo, a túnica trapézio sem mangas), resultam em um modelo mais amplo que pode abrigar corpos de tamanhos diferentes; no entanto, não exibem a mesma estética e/ou caimento para todos os tamanhos, significando que a proposta de forma, silhueta e caimento de uma peça pode não se repetir nos diferentes tamanhos. Ainda que um mesmo modelo vista diferentes tamanhos de corpos, é importante ressaltar que não se trata da graduação de tamanhos aplicada na indústria.

Assim, os modelos desenvolvidos necessitam ser estudados, cada qual na sua abordagem específica, e experimentados em suas possibilidades de graduação que pode requerer um processo de graduação específico, como o exemplo analisado da calça espiral. Vale lembrar que, mesmo com a graduação, o princípio de aproveitamento total de tecidos, ponto importante na presente pesquisa, deve ser, de alguma forma, respeitado.

Rissanen e McQuillan (2016) sugerem deixar áreas de tecido que poderão ser utilizadas de modo flexível, de acordo com os diferentes tamanhos.

Todas essas questões ficaram bastante visíveis durante a elaboração do protótipo da calça espiral, uma vez que o resultado, em termos de dimensões, não é previsível, e as variações das dimensões do tecido alteram bastante a peça final. Foi apenas a partir dos testes realizados com diferentes larguras e comprimentos de tecidos, que se pôde estimar as possibilidades de produção de outros tamanhos da peça.

Rissanen e McQuillan (2016) listam alguns caminhos possíveis em uma tentativa de resolver a questão dos diferentes tamanhos na modelagem *Zero Waste* e seus respectivos encaixes no tecido. São cinco propostas que podem ser avaliadas para aplicação em cada tipo de peça. As propostas dos *designers* são apresentadas a seguir e foram incluídas observações e comentários feitos pelos autores do presente trabalho.

1. Tamanho único: a graduação seria eliminada e peças seriam projetadas em um único tamanho, para vestir todos os corpos, ou um conjunto de tamanhos, porém, essa abordagem é limitada para peças de vestuário soltas, ajustáveis ou que envolvem o corpo (RISSANEN; MCQUILLAN, 2016). Importante ressaltar que um único tamanho, usado por corpos com diferentes medidas, pode resultar na alteração de aspectos estéticos da peça como caimento, forma e silhueta. O volume planejado para a peça no tamanho de corpo original, quando a modelagem *Zero Waste* foi elaborada, pode não ser o desejado para outros tamanhos. Além disso, a limitação da largura

do tecido pode limitar também o tamanho máximo da peça a ser construída, impedindo que determinadas peças possam ser produzidas em tamanhos maiores.

2. Graduação convencional: a familiaridade dos profissionais com a graduação convencional é um fator benéfico para que o processo ganhe velocidade. Mesmo que o tamanho original do traçado seja *Zero Waste*, a graduação convencional aplicada a outros tamanhos pode gerar encaixes que, provavelmente, resultarão em resíduos (RISSANEN; MCQUILLAN, 2016). Assim, após os moldes receberem as graduações, é improvável que o risco resultante esteja na mesma configuração do risco original (aquele projetado em *Zero Waste*) e um importante questionamento: "Pode-se afirmar que uma roupa seja *Zero Waste* se apenas o tamanho da amostra é *Zero Waste*?" (RISSANEN; MCQUILLAN, 2016, p. 160). Os autores do presente trabalho entendem que a resposta para essa pergunta é negativa. O processo de graduação convencional e o encaixe, tanto para modelagem convencional quanto para modelagem *Zero Waste*, possuem um mesmo fator limitante que é a largura do tecido. Desse modo, cada tamanho gerado vai necessitar de um encaixe diferente. Moldes construídos em *Zero Waste*, com formas mais geométricas, seriam mais facilmente resolvidos em um encaixe convencional, tendo como opção dividir o risco ou adicionar recortes, processo que já é possível e aplicável na indústria.

3. Projetando cada tamanho: cada tamanho da peça pode ser alvo de um planejamento e traçado específico, considerando a peça originalmente modelada como *Zero Waste*, como um guia.

   A partir dessa primeira etapa do estudo dos componentes a serem graduados, surgem duas opções: mudar ou manter, no risco, a configuração dos componentes da peça (RISSANEN; MCQUILLAN, 2016).

   a. Mudar a configuração do risco: após a graduação dos componentes para um determinado tamanho, é feito um novo risco, de modo a encaixar todos os componentes, utilizando 100% do tecido. Para manter a integridade do projeto, deve-se seguir o risco do original, tanto quanto possível (RISSANEN; MCQUILLAN, 2016). Entende-se que essa alternativa seja viável em termos de aplicação, mas nem sempre isso pode ser possível (encaixar utilizando 100% do tecido) – talvez seja necessário alterar alguns detalhes do risco original, adicionando recortes, por exemplo.

   b. Manter a configuração do risco: nesse caso, a primeira alternativa é alterar o volume total da peça para roupas que possuam recursos de volume que possam ser manipulados como pregas, pences, franzidos e dobras. Um vestido com pregas verticais pelo corpo, por exemplo, em seu tamanho menor teria mais pregas do que um tamanho maior, utilizando a mesma quantidade de tecido, porém, acrescentando mais volume à peça. A segunda alternativa é encaixar dois tamanhos da peça no mesmo risco. Como exemplo, em um encaixe com duas peças originais de tamanho M, poderiam ser cortadas uma peça P e uma G, compensando os espaços entre elas. No entanto, deve-se levar em conta que tanto a alternativa de manter o risco quanto a de mudar o risco podem ter limitações, quando aplicadas em determinadas peças, não sendo aplicáveis a um caso geral (RISSANEN; MCQUILLAN, 2016).

4. Diferentes larguras de tecidos para cada tamanho: uma alternativa seria o uso de tecidos com larguras diferentes para tamanhos diferentes citando, como um caso específico, malhas circulares, em que é possível controlar, no processo de fabricação, sua largura resultante (RISSANEN; MCQUILLAN, 2016).

   Os autores do presente trabalho entendem que, no mercado brasileiro, tecidos planos são fabricados com larguras similares (1,40 m ou 1,50 m), com poucas exceções. Assim, essa alternativa, proposta por Rissanen e McQuillan (2016), mostra-se aplicável apenas aos casos de peças em malha.

5. Método híbrido: é possível combinar os quatro caminhos anteriores (RISSANEN; MCQUILLAN, 2016).

Existem várias soluções para a graduação, mas elas dependem do tipo da peça, da variedade de tamanhos definidos pela empresa e das regras de graduação sendo que as soluções mais apropriadas são determinadas com base no tipo e estilo da peça, tipo e largura do tecido e, também, na grade de tamanhos desejada (RISSANEN; MCQUILLAN, 2016).

C-2. Mudança no paradigma do processo produtivo em confecções

> A abordagem da modelagem *Zero Waste* necessita de uma visão integrada do processo de desenvolvimento do produto. McQuillan (2011) menciona que o processo de *design* atual segue uma hierarquia separada de desenho, criação e modelagem, e que resulta em desperdício do têxtil e existe pouco risco ou pouca criatividade no processo rápido da moda atual sendo, dessa forma, mais fácil se inspirar em modelos com garantia de vendas a se arriscar na criação de algo novo. A abordagem *Zero Waste* pode "facilitar a transformação das hierarquias existentes no sistema de moda, com possíveis implicações positivas tanto para o *design* quanto para o processo de manufatura", já que os papéis tradicionalmente separados do *design* – modelagem, graduação, encaixe e montagem – são todos componentes indispensáveis do desenho de moda (RISSANEN; MCQUILLAN, 2016, p. 153, tradução nossa). Assim, no processo de fabricação, o "escopo do *design* se expande para graduação e encaixe" (RISSANEN; MCQUILLAN, 2016, p. 153, tradução nossa) e isso não significa eliminar uma ou mais funções no processo, mas melhorar a comunicação e promover trabalho conjunto que ocorre entre os diferentes papéis.

Muitas das limitações discutidas acima podem limitar ou impedir o uso da abordagem *Zero Waste* na produção de vestuário. No entanto, pode-se ver, também, que existem alternativas para transpor as limitações apresentadas, caso a empresa busque utilizar o *Zero Waste* como alternativa para a produção de vestuário, várias delas discutidas aqui. Ainda que as alternativas discutidas aqui sejam desafiadoras em sua implementação, como uso de recursos adicionais, tanto de tempo quanto de materiais (em alguns casos), elas mostram-se viáveis.

Durante o estudo e a elaboração dos protótipos, pôde-se notar a necessidade da visão integrada de todo o processo de *design*, estendendo-o aos aspectos mais técnicos de modelagem e encaixe, requerendo uma mudança essencial no paradigma atual da produção do vestuário. Essa mudança no ambiente industrial pode se tornar uma barreira difícil de se contornar. Além disso, a questão do tempo adicional, tanto para desenvolver algo novo como para replicar algo já existente na abordagem de modelagem *Zero Waste*, é um ponto importante que deve ser, também, levado em conta. Ainda que se busque a produção de peças inovadoras, possíveis a partir da modelagem *Zero Waste*, essas peças ficam restritas a um determinado público consumidor, que pode não ser interessante para as empresas.

5 CONCLUSÃO

O estudo da abordagem da modelagem *Zero Waste* ainda está presente, principalmente, no âmbito experimental. Trabalhos acadêmicos e experiências mostradas em eventos destacam o desafio da abordagem *Zero Waste* no vestuário, mas nem sempre as peças continuam sendo desenvolvidas, produzidas e comercializadas, dados os fatores já mencionados.

A *designer* McQuillan realizou pesquisa na indústria aplicando a abordagem da modelagem *Zero Waste* por meio de oficinas. Uma das empresas envolvidas na pesquisa alegou que o custo do tecido não compensava os custos adicionais, para se obter riscos mais eficientes, embora o resultado tenha sido satisfatório. A *designer* relata sua experiência com esse projeto como sendo uma arbitragem entre "o que existe" e "o que pode ser", sendo que "o que existe" vence devido à grande força que a indústria e sua complexidade exercem sobre aqueles que procuram mudá-la (MCQUILLAN, 2019, p. 156, tradução

nossa). No entanto, determinados recursos tecnológicos podem contribuir para que o *design Zero Waste* seja implementado nas indústrias, como o uso de *softwares* de modelagem 3D, por exemplo (MCQUILLAN, 2020).

Uma questão importante que também deve ser considerada é o aproveitamento total do tecido (em função do encaixe dos moldes para corte) da modelagem *Zero Waste* comparativamente a um modelo equivalente obtido com a modelagem convencional. Poucas são as discussões que analisam a eficiência dessa parte do processo, assim, considera-se importante uma análise sobre o consumo de material, para cada modelo elaborado, para que se possa afirmar que a modelagem *Zero Waste* é, de fato, mais econômica e pode ser mais interessante (apesar da necessidade de maior tempo e recursos despendidos para a criação de uma coleção). Pode-se afirmar que a aplicação da modelagem *Zero Waste* na produção em larga escala está condicionada a todos os fatores limitantes mencionados neste trabalho, o que torna sua execução ainda mais complexa. É um desafio estabelecer os recursos necessários para a produção das peças com a abordagem *Zero Waste*, pois cada projeto é único, com especificidades na modelagem, no encaixe, na graduação dos tamanhos e no tipo do têxtil. Além disso, requer ainda mudanças na forma de comunicação e de atuação dos profissionais envolvidos no processo. Assim, embora tenham sido apresentadas alternativas para contornar esses fatores limitantes, é importante questionar o interesse das empresas de confecção têxtil em utilizar a abordagem *Zero Waste* no seu processo produtivo, mesmo que recursos adicionais sejam necessários.

Traçar um paralelo entre as práticas de modelagem convencional e *Zero Waste* mostrou caminhos divergentes. Enquanto a modelagem convencional pode ser "segura e controlada", dentro da hierarquia seguida atualmente, a modelagem *Zero Waste* pode ser caracterizada por "incerta e desafiadora", necessitando mudanças na forma de se pensar a produção do vestuário.

A partir das reflexões sobre a aplicação do *Zero Waste* na modelagem, discutidas no presente artigo, importantes aspectos não foram abordados e devem ser considerados como possíveis trabalhos futuros: 1) pesquisa aplicada a empresas – para melhor análise da viabilidade e aceitação; 2) análise de consumo de modelagens/encaixes de outras peças, para se identificar, de forma geral, aspectos relacionados ao consumo de têxteis na abordagem *Zero Waste*; e 3) elaboração de análises e roteiros passo a passo para outras peças desenvolvidas pelos autores da área, visando atividades de ensino, de formação de profissionais e de produção.

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In this second edition of 2022, Sustainability in Debate's Editorial expresses a wake-up call, standing on circumstantial political aspects interrelated with the environmental crisis and reaffirming the role of open access scientific journals in the expansion of knowledge exchange. Science also needs to be democratized and sustainable, giving the entire scientific community access to the global production of knowledge that can contribute to making this world a better place.

In the *Varia* section, SiD publishes eight articles focused on the trajectory of construction and dismantling of forest policies in Brazil, specifically in the Amazon region; an investigation of the inclusion of Sustainable Development Goals in the Pedagogical Projects of Biology Degree Courses in the Amazon; a discussion on the motivations and difficulties in adopting sustainable practices in the supply chains of small and medium-sized companies in the cashew sector; an analysis of the impact of heat waves on the cardiovascular and respiratory health of a population in the Northeast region of Brazil; an investigation of cetacean observation tourism aiming to subsidize monitoring and inspection actions; the role of Energy Communities in promoting more sustainable, democratic and decentralized electrical systems; an analysis of the historical context of the establishment of the Ukrainian state, with a situational assessment of the current economic and environmental risks in Ukraine, in war times; and finally, an investigation of critical aspects and limitations of the creation and modelling process using the Zero Waste approach for application in the clothing industry.

Nessa segunda edição de 2022, Sustainability in Debate, em seu editorial, expressa um alerta, colocando-se sobre aspectos políticos circunstanciais inter-relacionados com a crise ambiental e reafirmando o papel dos periódicos científicos de acesso aberto na ampliação da troca de conhecimento. A ciência também precisa ser democratizada e sustentável, dando a toda comunidade científica acesso à produção global de conhecimento que pode contribuir para tornar este mundo um lugar melhor.

Na seção Varia, SiD publica oito artigos em diversos temas: uma trajetória de construção e desmantelamento de políticas florestais no Brasil, especificamente na Região Amazônica; uma investigação sobre a inclusão dos Objetivos de Desenvolvimento Sustentável nos Projetos Pedagógicos dos Cursos de Licenciatura em Biologia na Amazônia; uma discussão sobre as motivações e dificuldades na adoção de práticas sustentáveis nas cadeias de suprimentos de pequenas e médias empresas do setor de caju; uma análise do impacto das ondas de calor na saúde cardiovascular e respiratória da população na região Nordeste; uma investigação do turismo de observação de cetáceos visando subsidiar ações de monitoramento e fiscalização; o papel das Comunidades Energéticas na promoção de sistemas elétricos mais sustentáveis, democráticos e descentralizados; uma análise do contexto histórico no estabelecimento do Estado ucraniano, com uma avaliação situacional dos atuais riscos econômicos e ambientais na Ucrânia, em tempos de guerra; e, por fim, uma investigação dos aspectos críticos e limitações do processo de criação e modelagem utilizando a abordagem Zero Waste para aplicação na indústria do vestuário.

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