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Editorial

A year to be remembered

Marcel Bursztyn, Carlos Saito, Gabriela Litre, Patrícia Mesquita

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In 2020, in the editorial *Annus Horribilis* [SiD 11(1), we discussed the impact of the Covid-19 pandemic on all aspects of human life: health, economics, relationships politics-science, among others. Since science stepped up its efforts and developed vaccines in record time with great determination, hopes have been rekindled at the beginning of 2021. However, we end the year with unanswered questions.

If a significant percentage of the population refuses to be immunised and some governments do not consider the risks, how effective is vaccination?

Can risks be eliminated without ensuring the immunisation of the entire world population?

Economically more developed countries have acquired large vaccine doses in advance and stored them for future uses, reducing access to the poorest countries. What would be the way to strengthen countries' shared efforts for a globally immune population?

Can new variations of the coronavirus be prevented, and what is the relationship between these developments and the low vaccination rate of the population in some countries or regions?

What is the road towards social normality and economic activity at the pre-pandemic level?

And finally, how can we find a balance between respect for democracy for all and the right to freedom of choice when it comes to immunisation?

We have different answers to these questions, but the gap between reason and political decision-making is still vast. Countries with low economic growth, particularly in Africa, have insufficient access to vaccines. Like global climate issues, health challenges depend on universally-based solutions. The vaccine cannot be considered a commodity for share capital by the pharmaceutical industry or for economic power to guarantee future stocks. Well, not yet, anyway.

There are many lessons to be drawn from the human disaster this pandemic has caused. The global population needs mechanisms for action at the supra-national level. Overcoming economic, regional, social, racial and gender inequalities is crucial. Most vulnerable people are more than just part of the problem. They are the answer.

This vision of looking at the world from a pandemic perspective can also apply to other issues, like climate change, and we need to emphasise that.

This year was also marked by significant and extreme weather events (heatwaves, forest fires, heavy rains and floods). Progress was made at the 26th UN Conference of the Parties (COP-26) in Glasgow. It set out a higher commitment to reduce methane emissions (the global methane commitment[1]). Nevertheless, it has revealed extreme limitations since the pledges are not consistent, the objectives unclear, and the actual involvement of countries, lost in evasive proposals, especially in the short term. Brazilian participation at the Glasgow event was weak. The negligence and denial of governors

have reached high levels, with the retreat of environmental policy and the loss of information on an increased Amazon deforestation.

While the balance is a concern, this year is not to be overlooked. Instead, it should remain a warning for risks and an opportunity for new arrangements and practices to be adopted in scientific research.

In science, along with the extraordinary efforts to develop vaccines and treatments, other fields have shown a tremendous ability to adapt to the new era of social distancing. In the socio-environmental domain, many suspended field activities have been replaced by remote interaction with local actors and public officials until the situation returns to normal. The study teams included researchers and community members. This results in advances in the processes of knowledge construction, with a higher tuning between the questions of the academy and the real demands of society at the local level. The learning process has been rich, and a new research model with interactive and participatory virtual activities has come to stay.

One of the biggest lessons of 2021 is to affirm the importance of systemic and collaborative thinking as the best way to address the global crisis. Countries need to work together and give greater emphasis to equity.

millions of people in vulnerable situations work in poor conditions, confirming the "uberization of work" is also negative effect of the Coronavirus pandemic. How many cases of indignity and injustice remain? How many people suffer from food insecurity and hunger? Where and how are millions of people working under unacceptable conditions to allow others to have the kind of food, products and opportunities they want?

Just as we cannot address climate change without global and urgent action, we cannot build the means to confront present challenges by relying on top-down global measures. Greater solidarity is needed in local communities through bottom-up coordinated network actions.

This issue features 13 articles in the *Varia* section and a list of reviewers that collaborated with our team to assess all the manuscripts received during this year. Our gratitude goes out to all of them.

This final edition of 2021 presents an initial set of articles that look at sustainability in the textile industry. Scafuto *et al.* talk about the relationship between project management and green innovation in sustainable fabric companies. Albuquerque *et al.* discuss the pre-consumption textile waste management in the clothing industry in Teresina/PI.

In a second block, Assunção *et al.* address a management plan based on integrated and sustainable agroecological production for medicinal plants in Rio de Janeiro. Távora *et al.* discuss perceptions of rice farmers in the Jequetepeque Valley, Peru, and demonstrate the importance of integrated actions to promote complex innovations in agriculture. Mesquita and Cavalcante present the role of the Cisterns Programs (water infrastructure) for family farmers in strengthening adaptive capacities to climate change in the Brazilian semi-arid. Still, in the semi-arid region, Tiburcio assesses the Great Drought in the northeast of Brazil (1877-1879) and concludes that nothing explains the impact of this drought and famine. Santos *et al.* present an additional article on the water crisis in Sao Paulo in 2013. They analyse elements that confirm that this is a socially constructed risk.

In a more managerial field, Braga and Fonseca discuss the fact that environmental policies improve reactively (and not proactively) and use the catastrophes of Mariana and Brumadinho as examples. Then, Back *et al*. analyse the São Paulo's master plan from the point of view of principles and guidelines for a compact city, sustainable adaptation and ecosystem-based adaptation, focusing on real dynamics and conflicts. Silva *et al*. make the link between environmental management at the municipal level and the regional conservation of the Eastern Amazon from the viewpoint of public officials in the State

of Pará. Schossler *et al.* explore the lessons learned from a participatory methodology of ecosystem services assessment in the Uruguayan Pampa biome, the Tessa methodology (*Toolkit for Ecosystem Service Site-Based Assessment).* Bilyk *et al.* present the different approaches to introducing gender budgeting in countries as vital for ensuring sustainable development. And, finally, Campos *et al.* discuss the role of indigenous lands in the Amapá State for forest conservation.

We wish you all a good read and a healthy and peaceful New Year.

NOTES:

1 | https://ec.europa.eu/commission/presscorner/detail/en/statement_21_5766

Editorial

Um ano para não esquecer

Marcel Bursztyn, Carlos Saito, Gabriela Litre, Patrícia Mesquita

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Em 2020, abordamos em nosso editorial *Annus Horribilis* [SiD 11(1)], o impacto que a pandemia da Covid-19 estava provocando em todas as esferas da vida humana: na saúde, na economia, na relação entre a política e a ciência, dentre outras. O início do ano de 2021 trouxe esperança, já que a ciência trabalhou intensamente e com determinação, e desenvolveu vacinas em tempo recorde. Mas, chegamos ao final do ano com alguns pontos de interrogação:

Até que ponto as vacinas são uma garantia contra os riscos da pandemia, se parte da população se recusa a ser imunizada e alguns governos não dão a devida importância aos riscos?

É possível eliminar os riscos sem que toda a população do planeta esteja devidamente imunizada?

Como combinar o esforço de algumas nações em imunizar sua população com a ideia de uma imunização planetária, visto que as economicamente mais desenvolvidas adquiriram antecipadamente grande quantidade de doses de vacinas e fizeram estoques para futuro reforço em sua população, reduzindo o acesso às populações dos países mais pobres?

Como evitar o surgimento de novas cepas do Coronavírus e qual a relação entre o surgimento dessas novas cepas e o baixo nível de vacinação populacional de um determinado país ou região?

Como buscar a volta à normalidade social e das atividades econômicas, aos níveis pré-pandemia?

Como conciliar a democracia para todos e a defesa dos direitos de alguns a não se vacinarem?

São perguntas para as quais temos algumas possíveis respostas, mas o hiato entre a razão e as decisões políticas é muito grande. Países com baixos níveis de desempenho econômico, principalmente na África, ainda têm pouco acesso às vacinas. E sabemos que, da mesma forma que os grandes problemas ambientais mundiais, os desafios da saúde também dependem de soluções universalmente abrangentes. A vacina não pode, neste momento, ser tratada como mercadoria, seja para acumulação de capital pelo setor farmacêutico, ou no exercício de poder econômico e corrida para garantia de estoques futuros.

Muitas lições podem ser tiradas do drama humano imposto pela pandemia. O planeta precisa de mecanismos de ação em escala supranacional. É imperativo superar as desigualdades econômicas, regionais, sociais, raciais, e de gênero. As populações mais vulneráveis não são apenas parte do problema; elas são parte da solução.

Essa mesma forma de olhar para o mundo a partir da pandemia também se aplica ao enfrentamento de outros desastres, como as mudanças climáticas, e devemos chamar a atenção para isso.

O ano de 2021 foi também marcado por importantes eventos climáticos extremos (ondas de calor, incêndios florestais, chuvas intensas e enchentes). A Conferência das Partes da Convenção do Clima das Nações Unidas (COP 26), realizada em Glasgow, trouxe avanços, no sentido de compromissos para

a redução das emissões de metano (Compromisso Global de Metano[1]). Mas revelou limitações graves, já que os compromissos são pouco consistentes, as metas pouco precisas e o efetivo envolvimento dos países acabou diluído em propostas evasivas, principalmente no curto prazo. No Brasil, cuja participação no evento de Glasgow foi marginal, a negligência e o negacionismo dos governantes chegou ao paroxismo, com fortes retrocessos nas políticas ambientais e escamoteamento de informações sobre o desmatamento da Amazônia, que sofreu forte avanço.

Ainda que o balanço seja preocupante, este ano não deve ser considerado como um momento a ser esquecido. Ao contrário, deve ser lembrado, como advertência aos riscos e como oportunidade para que novos arranjos e práticas sejam adotados na pesquisa científica.

No campo da ciência, ademais do formidável esforço que levou ao desenvolvimento das vacinas e de tratamentos, outros campos também mostraram uma enorme capacidade de adaptação aos novos tempos do distanciamento social. Na área socioambiental, muitas atividades de campo que ficariam suspensas até a volta aos tempos normais, passaram a ser substituídas pela interação remota com atores locais e agentes públicos. Pesquisadores cidadãos, membros das comunidades, foram incluídos em equipes de estudo. O resultado tem sido um grande avanço em processos de coconstrução de conhecimento, com maior grau de sintonia entre as perguntas formuladas na academia e as reais demandas da sociedade em nível local. O aprendizado tem sido rico, e um novo molde de pesquisa, com base em interações e processos participativos virtuais, parece ter vindo para ficar.

Um dos maiores aprendizados de 2021 é a confirmação da importância do pensamento sistêmico e colaborativo como a melhor forma de enfrentar as crises globais. Os países devem trabalhar juntos e com um maior foco na equidade. Milhões de pessoas empregadas em condições precárias e altamente vulneráveis, e a dita "uberização do trabalho" é apenas uma situação extraordinariamente ruim revelada pelo Coronavírus. Quantas situações deste tipo de indignidade e iniquidade ainda existem? Quantas pessoas ainda estão expostas à insegurança alimentar e fome? Onde e como milhões de pessoas estão trabalhando em condições inaceitáveis para permitir que outros tenham o tipo de alimento, produtos e oportunidades que querem?

Por outro lado, assim como não podemos lidar com a mudança climática sem uma ação global, que é realmente urgente, precisamos lembrar que os seres humanos não serão capazes de encontrar caminhos frente aos desafios atuais confiando apenas em ações globais, de cima para baixo. É necessário maior solidariedade em nível local, comunitário, de baixo para cima, com ações coordenadas e em rede.

A presente edição de SiD apresenta 13 artigos na seção *Varia* e também a lista de pareceristas que colaboraram com a avaliação dos trabalhos recebidos ao longo do ano. A todas e todos eles e elas somos imensamente gratos.

Nessa edição final de 2021, apresentamos um primeiro bloco de artigos relacionados à sustentabilidade da indústria têxtil. Scafuto *et al*. discutem sobre a relação entre a gestão de projetos e a inovação verde em empresas de tecidos sustentáveis, seguido por Albuquerque *et al*. com uma exposição sobre o gerenciamento dos resíduos têxteis pré-consumo da indústria de confecção do vestuário em Teresina (PI).

Em um segundo grupo de artigos, Assunção *et al.* apresentam um plano de gestão baseado na tecnologia de Produção Agroecológica Integrada e Sustentável (PAIS) para cultivo de plantas medicinais no Rio de Janeiro, e Távora *et al.* discorrem sobre a as percepções de produtores de arroz do Vale do Jequetepeque, no Peru, demonstrando a relevância de ações integradas para promover a adoção de inovações agrícolas. Mesquita & Cavalcante debatem sobre o papel do Programa Cisternas (de infraestrutura hídrica) para os agricultores familiares, focando no fortalecimento das capacidades adaptativas às mudanças climáticas no Semiárido Brasileiro. Tibúrcio, ainda tendo o Semiárido como foco, discorre sobre a Grande Seca da região (1877-1879), chegando à conclusão que não há muitos indícios que satisfatoriamente expliquem a magnitude do impacto da seca e fome nesse período. Ainda

no tema de escassez hídrica, Santos *et al.* apresentam uma discussão sobre a crise hídrica de São Paulo em 2013, trazendo elementos que corroboram para o entendimento que o risco de escassez de água é socialmente construído.

Mais relacionado à gestão, Braga & Fonseca discutem como as políticas ambientais se aperfeiçoam de modo reativo (e não proativo), usando os desastres de Mariana e Brumadinho como exemplos. Em seguida, Back *et al.* apresentam uma análise do Plano Diretor de São Paulo à luz dos princípios e diretrizes sobre cidade compacta, adaptação sustentável e adaptação baseada em ecossistemas, focando nas dinâmicas e conflitos existentes. Silva *et al.* discutem a ligação entre a gestão ambiental municipal e a conservação regional na Amazônia Oriental, de acordo com a percepção de agentes públicos do estado do Pará. Já Schossler *et al.* exploram as lições aprendidas da aplicação de uma metodologia participativa de avaliação de serviços ecossistêmicos no bioma Pampa Uruguaio, o método Tessa (*Toolkit for Ecosystem Service Site-Based Assessment*). Bilyk *et al.* discutem as abordagens para a introdução do orçamento de gênero dos países, um elemento vital para a garantia do desenvolvimento sustentável. E, por fim, Campos *et al.* discutem o papel das terras indígenas no estado do Amapá para a conservação florestal.

Desejamos a todas/todos uma boa leitura e um final de ano de saúde e paz.

NOTES:

1 | https://ec.europa.eu/commission/presscorner/detail/en/statement_21_5766

Project management relationship to green innovation processes in sustainable fabric companies

Relação entre gestão de projetos e inovação verde em empresas de tecidos sustentáveis

Isabel Cristina Scafuto [1]

Valdemilson de Assis Alves de Araújo [2]

Andrea dos Anjos Moreiras [3]

Cláudia Terezinha Kniess [4]

[1] *PhD in Administration, Professor and Researcher, Programa de Pós-Graduação em Gestão de Projetos, Universidade Nove de Julho (Uninove), São Paulo, Brazil*
E-mail: isabelscafuto@gmail.com

[2] *Master's Degree in Administration, PhD Student, Programa de Pós-Graduação em Gestão de Projetos, Universidade Nove de Julho (Uninove), São Paulo, Brazil*
E-mail: araujovaa.gp@gmail.com

[3] *Master's Degree in Environmental Management and Sustainability, PhD student, MBA Fashion Professor, Programa de Pós-Graduação em Design, Universidade Anhembi Morumbi (UAM), São Paulo, Brazil*
E-mail: andrea@universoeco.com.br

[4] *PhD in Materials Science and Engineering, Professor and Researcher, Universidade Federal de São Paulo (Unifesp) and Universidade São Judas Tadeu, Collaborating Researcher, Instituto de Estudos Avançados da Universidade de São Paulo (IEA/USP-CG), São Paulo, SP, Brazil*
E-mail: kniesscl@gmail.com

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ABSTRACT

The concept of green innovation refers to innovation that seeks to make radical or progressive improvements to products or processes that contribute to sustainable development. Green innovation can improve the global image of a business and lead to better market performance. Green innovation projects can contribute to economic growth and a positive quality of life without negatively affecting the environment. Consequently, this study aims to examine the relationship between the development of green materials resulting from green innovation and project management. To achieve the research objective, we conducted a multi-case study with companies developing green innovation derived textile. The findings show that the firms surveyed do not use formal project management to execute their green innovation projects and that their project management is intuitive. Although the companies

surveyed are concerned with sustainable development and strive to innovate to satisfy their customers responsibly, their project management practices are informal. This study contributes to the practice. It is possible to introduce project management into enterprises to enhance green innovation while adapting practices or using less formal and bureaucratic techniques.

Keywords: Management of Innovative Projects. Sustainable Project Management. Green Innovation. Sustainable Fabrics.

RESUMO

O conceito de inovação verde refere-se ao tipo de inovação dedicada para a obtenção de melhorias radicais ou incrementais de produtos ou processos que contribuam para o desenvolvimento sustentável. A inovação verde pode melhorar a imagem geral de uma empresa e, como consequência, pode levar a um melhor desempenho no mercado. Os projetos de inovação verde podem colaborar para o crescimento econômico, possibilitando qualidade de vida sem prejudicar o meio ambiente. Assim, o objetivo deste estudo é verificar como se caracteriza a relação do desenvolvimento de tecido derivado da inovação verde com o gerenciamento de projetos. Para alcançar o objetivo da pesquisa, foi realizado um estudo de multicasos com empresas desenvolvedoras e utilizadoras de tecidos derivados da inovação verde. Os resultados obtidos indicam que as empresas estudadas não usam gestão de projetos formal na condução de seus programas de inovação verde. A gestão de projetos é totalmente intuitiva. Embora as empresas pesquisadas estejam preocupadas com a sustentabilidade e querendo cada vez mais inovarem com responsabilidade para satisfazerem seus clientes, as práticas de gestão de projetos são informais. Este estudo contribuiu para a prática, no sentido de que existe a oportunidade de implementação da gestão de projetos nas empresas com o intuito de melhoramento da inovação verde, embora com a necessidade de adaptação ou uso de técnicas menos formais e burocráticas.

Palavras-chave: Gestão de Projetos Inovadores. Gestão de Projetos Sustentáveis. Inovação Verde. Tecidos Sustentáveis.

1 INTRODUCTION

The academic community and companies have progressively expressed interest in sustainability, which directly triggers increased pressure on companies to recognise ecological awareness (HART, 2005). Innovation has been recognised as an ally of sustainability, so that it is part of the strategic agenda for creating a competitive advantage for companies (SHAFIQUE, 2013). This is considered a critical factor for developing a more inclusive and sustainable world, which "involves creating and disseminating new products, processes, and methods" (OECD/Eurostat, 2015). Innovation is not a final objective but the fundamental basis for creating new businesses and jobs, and consequently, for the economic development of nations.

The literature presents different ways to integrate Innovation and Sustainability themes, such as green innovation, ecological, environmental, and sustainable innovation (TARIQ *et al.*, 2017). This research addresses green innovation, defined as new products and processes that provide value to customers and businesses and significantly mitigate adverse environmental impacts (KONG; FENG; YE, 2016). Green product innovation generates the design, production, and sale of products with no significant adverse effect on the environment throughout the product's life cycle. It includes ensuring efficient use of materials and reducing pollutants (AMBEC; LANOIE, 2008). Green process innovation is seen as progress in technologies and processes that create products with little or no negative environmental impact (HUANG; LI, 2017; SEZEN; ÇANKAYA, 2013). One example is recycling materials to reduce waste and improve inputs, thus contributing to profitability (FRAJ-ANDRÉS; MARTINEZ-SALINAS; MATUTE-VALLEJO, 2009).

Green innovation can improve a company's overall image and lead to better performance in the market (TARIQ *et al.*, 2017). The positive reputation associated with green innovation increases the company's

market value (MAJUMDAR; MARCUS, 2001). Better environmental performance can facilitate new market opportunities, improve the public image or prestige, increase customer loyalty, and support sales efforts (AMBEC; LANOIE, 2008).

There is a gap in the management level of companies concerning the incorporation of aspects of sustainability into organisational processes. Therefore, there is a need for the environmental, social, and economic dimensions to be inserted and worked into the project management function and in product development, thus aiming at sustainability (AARSETH *et al.*, 2017; HERNÁNDEZ *et al.*, 2020; SABINI *et al.*, 2019). Projects characterised as "green innovation" can collaborate with economic growth, enabling positive quality of life without harming the environment (BOTKIN; KELLER, 2011). However, small and medium companies (SMEs) have difficulties in using project management practices (TURNER; LEDWITH; KELLY, 2010), especially in sustainability, due to increasing complexity (ESKEROD; HUEMANN, 2013; SILVIUS *et al.*, 2012).

The growing concern with the environment has influenced the textile industry as it is responsible for negative impacts related to pollution (CHEN *et al.*, 2017; SAN *et al.*, 2018). To minimise pollution caused by the textile industry is one of the main concerns for sustainability (AMINDOUST; SAGHAFINIA, 2016). Innovative fabrics with sustainable appeal have been created over the years (VALLE *et al.*, 2004). Although not yet prevalent, sustainable materials are gaining space among brands (COLERATO, 2016), inspiring innovation in the fashion market.

Many innovative sustainable fabric companies are small or medium-sized, and innovation through entrepreneurial activity is usually essential for its contribution to the economy and the development of green innovation. This study aims to verify the character of the development of fabrics derived from green innovation and project management. We performed a multi-case study with companies that develop technologically innovative and sustainable materials to achieve the research objective.

The results indicate that despite the potential of using project management tools to improve green innovation, SMEs dedicated to sustainable fabric products do not use formal techniques to manage their projects. We would argue that it's because of its size and the technical focus on innovation development.

2 THEORETICAL FOUNDATION

2.1 INNOVATIVE GREEN PROJECT MANAGEMENT

The growth of industrial activity, with the consequent generation of a more significant amount of waste and pollutants along with the increase in demand for products and services, has forced the simultaneous development of new technologies for production processes with the need for further administrative techniques aimed at managing these activities while attuned to environmental concerns (SABINI *et al.*, 2019). Concurrently, governments began to dedicate efforts to searching for solutions to environmental problems through specific regulatory bodies and the attempt to implement agreements resulting from international conferences. Standardising bodies started to work on technical standards to guide companies (AGARCHAND; LAISHRAM, 2017).

The project management area has taken on an essential role in companies, going through a transformation process, organising itself to provide effective and agile answers to the questions that belong to it (CARVALHO; RABECHINI JÚNIOR, 2011). Innovation and the development of new products and/or services are strongly associated with modern project management (COUTINHO; GIL, 2013). Rational project management approaches include ways to address the unexpected (SICOTTE; DROUIN; DELERUE, 2014), thereby helping achieve the goals of a new product and/or new business technology (COOPER; EDGETT; KLEINSCHMIDT, 1999; ROUSSEL; SAAD; ERICKSON, 1991).

Innovative green projects can contribute to economic growth, enabling positive quality of life without harming the environment (AARSETH *et al.*, 2017). Many companies apply good project management practices, and this area has gained importance in companies seeking agile responses in their business processes and projects. Sustainability has aroused the interest of professionals and researchers in project management (SILVIUS; SCHIPPER, 2015). Even so, there is a gap between understanding and using sustainability in project management practice (MARTENS; CARVALHO, 2016). Several scientific works are available in sustainability and project management, but no research links the two areas (MARTENS; CARVALHO, 2016).

It is critical to emphasise the application and learning process around green innovation generates an advantage in improving, minimising cycle times, and unnecessary procedures in production (SERRANO-GARCÍA *et al*., 2021). Project managers need to be relatively autonomous to overcome each raw material's legislative and technological challenges in a sustainable and innovative product or process (WILLEMS *et al*., 2020). To become competitive, managers must use their knowledge or skills to apply important green strategic innovations (SERRANO-GARCÍA *et al*., 2021).

This work aims to verify the relationship between developing innovative green products and project management in SMEs. To understand this relationship, we used fabrics made with green innovation technology as the focus of our study.

2.2 SUSTAINABLE FABRICS

Sustainable fabrics are gaining space among brands that are thinking about best practices for sustainable production. In general, the focus of innovation projects in the textile industry has been the exchange of synthetic materials for natural materials (NAYAK; MISHRA, 2016; ZHANG *et al*. 2016) and the search for less pollutant manufacturing processes (BENLI; BAHTIYARI, 2015; EL-GOHARY *et al*., 2013; LI *et al*., 2018).

These fabrics are increasingly inspiring innovation in the fashion market (SU-YUN; JUNG-MIN, 2010). One of the most common types of eco-friendly fabric is defibrated (CANDIDO, 2021). Defibrated fabrics are those with yarns obtained using defibrated material from longstanding tissue waste. Research and new developments allowed the fashion market to start using them to produce new products. Defibrated fabrics have resistance, are comfortable and attractive. In addition to the environmental issues that make the fi more attractive than conventional fabrics, the appearance is another positive advantage of the product (PALME *et al*., 2017).

Sustainable and innovative textile raw material alternatives are steadily emerging. They are not harmful to the environment and use materials that would be discarded (CANDIDO, 2021). In Frame 1, we present some alternatives that entered the market to help strengthen this niche (MAGAZINE, 2020):

Frame 1 | Sustainable and innovative textile raw material alternatives

Kind of Fabric	*Description*
Organic cotton	Reduced use of chemicals, in addition to other natural resources
Hemp	One of the most sustainable vegetable fibres in the world. It is grown near rivers and produced from the Cannabis sativa plant, and it does not need chemicals like herbicides and pesticides to grow.
Banana fibre	It is extracted from the trunk of the banana tree, thus avoiding its disposal. Material of excellent resistance and looks like silk and cotton.

Kind of Fabric	Description
Orange fibre	Made from the orange pulp cellulose used in juice factories, the orange has a finish like that of silk.
Pirarucu leather	A fish native to the Brazilian Amazon and its cultivation is one of the primary sources of income for families in this region.
Soy fibre	Made from leftover soybean processing, soy silk is another sustainable fabric.
Lenpur	Made from the white pine tree, lenpur is a soft biodegradable fabric with a great absorption capacity and moisture release.
Linen	Linen is a sustainable fabric used since ancient civilisations. The fibres are removed from its stem and root.
Lyocell	Lyocell is a fiber that uses chemicals free of harmful solvents in its production. It is made from wood pulp.
Modal	It is made from the bark of wood. The material is extracted in the same place where the fibre is produced.
Piñatex	Extracted from the pineapple fibres and is leather. It has the same function as animal or synthetic leather and does not generate extra costs for its production, such as water or pesticides.
Degradable polyamide	Developed so that clothing can decompose more quickly after being discarded, biodegradable polyamide is a fibre that degrades in just three years.
Qmilk	It comes from milk protein, from curdled milk that the industry would discard. In addition to being an all-natural fibre, it requires low water consumption and no addition of chemicals.

Source: Adapted from MAGAZINE (2020)

3 METHODOLOGICAL PROCEDURES

3.1 RESEARCH DESIGN

We designed the research to minimise the external variation of the studied phenomenon (EISENHARDT, 1989). The authors considered some theoretical dimensions relevant to fabric companies' choice as a sample for data triangulation. We selected the companies based on two criteria applicable to the research. First, they would have to be classified as being sustainable. Second, they would have to work with fabrics developed with technological innovation. The selected companies are consolidated sustainably and innovatively market, which meets the profile established by this research proposal. The intention of researching sustainable and innovative fabrics is to show the fashion industry that sustainable alternatives do not harm the environment and generate a competitive advantage for companies, aiming at the tripod of sustainability.

3.2 DATA COLLECTION

To conduct the research, we used multiple sources of evidence (EISENHARDT, 1989). This process implemented the triangulation of primary and secondary data: information from websites, news, company documents, bibliographic research on the subject, and semi-structured interviews with executives of the manufacturing companies. Thus, to conduct interviews with the managers of the fabric companies, we analysed the secondary data sources. This was so that the researcher could become familiar with the companies before starting the semi-structured interviews. Additionally, it helped with triangulation and the development of an essential document for later analysis of cases. Although the primary data source is derived from semi-structured interviews (SAUNDERS; THORNHILL; LEWIS, 2009), this other information facilitated the elaboration of the questions used in the interviews and the later triangulation of the data. Knowing the intentions and experiences of key actors directly involved in projects to develop green innovation fabrics is essential. We concluded the interviews with some precautions for their conduct, such as the use of short expressions, rewording, and supplementary questions (SAUNDERS; THORNHILL; LEWIS, 2009).

Frame 2 presents the companies participating in the research, the interviewees, and their respective positions.

Frame 2 | Companies and their key players with their respective positions

Company	*Code*	*Position in the company*
Movin	E1	Managing partner
Anicet Clothing and Services in Fashion and Style Inc. (Contexture)	E2	Managing partner
Cotton Move	E3	Managing partner
Natural Cotton Color	E4	Managing partner

Source: The authors.

Frame 3 shows the script for the semi-structured interviews. The elaboration of the questions observed a previous validity relating the research to the theory.

Frame 3 | Semi-structured interview script

Questions	*Theoretical foundation*
Descriptive information of the interviewees and the company: name of the interviewee, name of the company, and the interviewee's position, etc.	
Would you please tell me your company's story and how the idea of sustainable fabrics was born?	Candido (2021), Colerato (2016)
What are sustainable fabrics in the concept established by the company?	Candido (2021), Colerato (2016)
What types of fabric are manufactured today, and what characterises them as sustainable?	Su-Yun and Jung-Min (2010), Colerato (2016), Tariq *et al.* (2017).
How was the first sustainable product developed?	TARIQ *et al.* (2017)
From this, how is the project management of the development of the new fabrics' project?	Martens and Carvalho (2016)
Planning - Is there any formalisation of the fabric development project, in which aspects of the project's scope, time to completion, development cost, materials, and suppliers are discussed, as well as steps and actions to make it happen? If so, how does it happen?	HAANAES *et al.* (2011)
Execution, Monitoring and Control - How does the project run? Does the development project take place separately from the production? Are there formal follow-up meetings? Is there a person responsible for development? Are there controls to assess progress? How are interventions made to correct the directions? Are there records of fabric developments?	HAANAES *et al.* (2011).
Closure - How does it happen, and what are the decision criteria that the project is closed - fabric ready to produce and sell? Is there any criterion for evaluating the success of the executed project? Are records of the entire project and the steps kept supporting future developments?	Martens and Carvalho (2016), HAANAES *et al.* (2011).

Source: The authors.

4 RESULTS

4.1 MARKET CHARACTERIZATION

Starting in the 1990s, the fast-fashion market proliferated. According to the BBC, the fashion industry occupied second place in the ranking of the most polluting in the world (JORNALISMO NIC, 2018). Faced with this dilemma, concern for a better world awoke new habits in the population, and sustainable fashion or eco-fashion emerged. Realising this need for change in the fashion sector, sustainable fashion is still timid and covers approximately 5% of the Brazilian population (JORNALISMO NIC, 2018).

The growth of the sustainable fashion sector suffers some obstacles, such as heavy investment in research and development in technological innovation. Another factor, which can be considered an obstacle, is the product's price that reaches the final consumer. They are still more expensive than fast fashion. This is due to artisanal confection and on a smaller scale. Another factor to consider is fair trade; the professionals involved in designing, cutting, and sewing receive a fair wage. Thus, this timid change that has arisen in fashion requires awareness for the product's whole life cycle and the consumer. Slow fashion is already a reality and addresses improved environmental, social and transparency conditions in the production line (JORNALISMO NIC, 2018).

4.2 CHARACTERIZATION OF THE STUDIED COMPANIES

The following sections present the companies participating in the research and their main characteristics.

4.2.1 MOVIN COMPANY

Movin was founded in 2011 in Rio de Janeiro with the main idea to bring the sustainability tripod as a fundamental pillar of ethics and bring design and technology. The company launched all products as initiatives that were truly sustainable through research. Since 2011, the company has been transparent about bringing innovations, solutions for fabrics, other processes within the company, and communication.

4.2.2 COMPANY ANNE ANICET CLOTHING AND SERVICES IN FASHION AND STYLE INC. (AA FASHION) – CONTEXTURE

Anne Anicet Clothing and Services in Fashion and Style Inc (AA Fashion) – Contexture is in Porto Alegre, RS – Brazil. Contexture is a South Brazilian brand of ethical fashion with a slow-fashion philosophy. Companies cut their pieces through artistic processes so that new relationships can be established in use. This is based on textures as raw material and sustainability to improve the quality of life.

4.2.3 COTTON MOVE COMPANY

Cotton Move, founded in 2018, is from São Paulo. It is a textile company that produces jeans using recycling techniques and believes it can transform fashion into quality products. Its mission is to propagate a sustainable fashion concept that meets the needs of the conscious consumer. Their objectives are to develop research and technology and manufacture and distribute products while generating capital and profits without disrespecting the environment.

4.2.4 NATURAL COTTON COLOR COMPANY

Natural Cotton Color was established in 1995 in Paraíba as a streetwear fashion, under the name of its founder and managing partner, Francisca Vieira. In 2001, it included local handicrafts in its collections and participated for the first time in a fashion event: The National Textile Industry Fair – NTIF. As of 2005, Natural Cotton Color works strictly with the Paraíba Colored Cotton developed by the Brazilian Agricultural Research Company – Embrapa, cotton whose plume is born in brown and beige tones, without the use of additives or dyes. It also added artisanal work in designing its products – aligning the brand with eco-friendly and sustainable fashion.

4.3 GREEN INNOVATION AND ITS RELATION TO PROJECT MANAGEMENT

The results of the qualitative analysis of the semi-structured interviews were processed using the MAXQDA software, which produced a map (Figure 1). The numbers identified in the figure represent the number of co-occurrences coded by the researcher. Extracts complement the presentation of the results from the interviews for a better understanding of the reader. Each respondent was identified with a code verified in Frame 2.

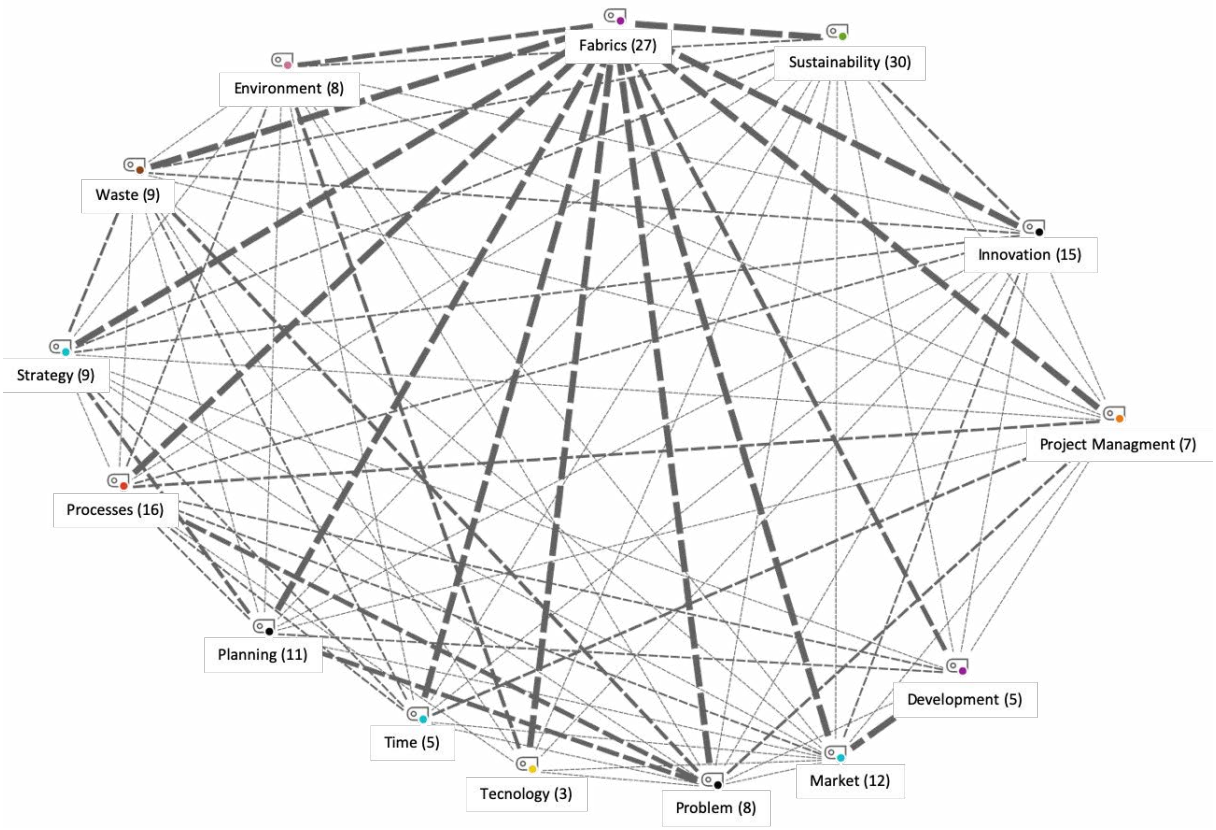

Figure 1 | Green innovation and possible relations with project management

Source: The authors

From Figure 1, it is possible to check the relationships between the codes identified in the interviews with companies developing green innovation fabrics. The principal codes extracted from the research are project management, sustainability, and innovation. These codes are directly related to the research objective. Innovation and sustainability are closely linked and were frequently mentioned during the interviews. This high number of citations is due to the research object, the fabrics developed with technological and sustainable innovations. It is possible to verify this strong relationship based on statements made by some interviewees.

The interviewee of the company Contexture (E2) reported that "Apply theories sustainably in practice and check what worked and what didn't. With that, over the years we have been testing various sustainable strategies, some have worked, others not so much".

According to the interviewee (E3), manager of the company Cotton Move,

> At the suggestion of a business partner, we decided to focus on defibration because the problem of textile waste is more serious than the problem of cotton. In this context of conventional cotton and organic cotton production, waste is more problematic. There are not hundreds, but thousands of tons per day, per month, which does not have a solution, here in Brazil.

There is a concern with some innovations considered sustainable, seen in the interview of the company Natural Cotton Color, interviewee (E4):

> So, we try to put the tripod of sustainability and the cultural part in a brand and, for me, this I can call sustainability. It is not always possible to have four pillars, but it is difficult if you do not have at least two. For me, the recycled PET is not to push the problem to tomorrow; you know that problem that we have to solve today.

The interviewee shows concern about the fabric made of plastics originating from the PET. This is because there is a discussion regarding the disposal of this type of fabric and microplastics.

Sustainability relates to other codes that are important for understanding relationships with a whole, such as fabrics. All companies interviewed are manufacturers or develop products from sustainable fabrics. Another interesting connection is that of sustainability with strategy, and respondents made this relationship explicit. Respondents stated that an essential strategy for the company is to work with the green innovation fabric differential. They still use methods to understand the market and manufacture new fabrics. This is evident in the speech of interviewee E1 who reported: "based on results and market information, as we do not produce from our idea, that is, we do not find and simply launch a product. First, we research to understand what the consumer wants, to produce later". Another statement that has a strong relationship with strategy comes from the interviewee E2: "With this, over the years we have been testing various sustainable strategies, some have worked, others not so much".

With the project management code, the relationship is not as strong with the themes of sustainability and innovation. The interviewees talked about working with projects, but it is transparent that it is not formally, but intuitively. For example, in the interviewee's E3 report, project management is timidly related to sustainability and innovation: "Water, energy, labour. So, the more we can recycle, and I don't just say that in my area. Today we focused on jeans, but, at various stages of the project, we are going to get fabrics and other fibres".

It is observed that interviewee E3 talks about the concern with sustainability, the search for new fabrics with green innovation, and mentions the stages of the project. However, there is no evidence in the interviews that prove the proper use of project management or even reports the existence of a collaborator focused on the conduct of projects. This lack of connection with project management is evident in the interviewee's E4 statement: "The creation of a new product is a straightforward thing, there are no major studies, research, I have to have a supplier, input, which is cotton, then spin, weave, transform into clothes and sell. So, there is not much to plan".

Project management is also related to the processes in the companies surveyed. This is because the interviewees show they control the processes within the design of each product. Regarding this, interviewee E3 reports: "The records are already made in the product's technical sheet, in the Excel spreadsheet and where it is done even the records of what is produced in that article". Generally, jeans articles have a slightly longer life cycle than other pieces. The final product has some samples where

some customers participate in the decision process. The success of the sale will determine how long the product will survive in the sales arena. If it is a best-seller, it can be maintained throughout the entire collection. It can be produced in several units, or it simply may not be to the consumer's liking and then in the next project, we understand the errors, redo the adjustments, and adapt to produce a new product for the vision that the consumer has to acquire the product.

5 DISCUSSIONS

This study aimed to verify the characteristics of the development of fabrics derived from green innovation and project management. We studied companies that manufacture or develop fabrics derived from the sustainable technological innovation process to accomplish this. We interviewed managers of four different companies. In addition to the semi-structured interviews, we collected secondary data, such as information on the companies' websites, reports, and documents. These data served to triangulate the data. This multiple case study made it possible to analyse real experiences in the context of the chosen theories.

Factoring in the growing awareness of the need to minimise the environmental impact of the textile industry (AMINDOUST; SAGHAFINIA, 2016; SAN *et al.*, 2018), and the interest in sustainable fabrics (COLERATO, 2016), it is important to assess the role of SMEs dedicated to this type of product. In this study, these SMEs can be classified as sustainability-driven companies (ALBINO; BALICE; DANGELICO, 2009). The statements indicate that their interest goes beyond the interest of legitimacy and financial gain (TARIQ *et al.*, 2017) of sustainability-driven innovation (KIRON *et al.*, 2013).

This represents the genuine interest of the interviewed entrepreneurs of these studied companies. Although, they also believe that green innovation is a differential to stand out in the increasingly competitive strategic market. For example, although defibrated fabrics use defibrated material from fabric scraps, like PET, some entrepreneurs said this mitigates but is not a definitive solution. They prefer to substitute for natural materials (NAYAK; MISHRA, 2016; ZHANG *et al.*, 2016) and improve their production process to become more sustainable (BENLI; BAHTIYARI, 2015; EL-GOHARY *et al.*, 2013; LI *et al.*, 2018).

Companies realize that working with green innovation is a smart strategy in such a competitive market. Despite the recognition of entrepreneurs that their companies participate for a more sustainable world, it also explains the positive reputation associated with green innovation and the possibility of these companies to capture value (MAJUMDAR; MARCUS, 2001). Better environmental performance can facilitate new market opportunities, improve the public image or prestige, increase customer loyalty, and support sales efforts (AMBEC; LANOIE, 2008).

The studied entrepreneurs said they work with projects. Still, it seems to indicate that they are more concerned with the technical features of the sustainable product project. We identified the replacement of synthetic by natural fabrics (MISHRA, 2016; NAYAK; TONG, 2016; ZHANG *et al.*, 2016), and materials and techniques to turn the production process more sustainable (BENLI; BAHTIYARI, 2015; EL-GOHARY *et al.*, 2013; LI *et al.*, 2018). Their focus does not consider the use of project management tools or best practices.

Our results indicate that SME entrepreneurs do not see an immediate reward for using the project management tools. They have little knowledge about project management tools and practices but believe it will be difficult (TURNER; LEDWITH; KELLY, 2010), and complex to use (ESKEROD; HUEMANN, 2013; SILVIUS *et al.*, 2012).

They do not consider project management a competitive differential, as they manage their projects informally within the companies. Project management practices are not usually considered by SMEs, especially companies that are technically oriented. Project management practices tend to be formal and considered bureaucratic by SME managers (TURNER; LEDWITH; KELLY, 2010).

However, the use of project management practices may improve sustainable, innovative product development (CARVALHO; RABECHINI JÚNIOR, 2011; COUTINHO; GIL, 2013), helping to achieve the goals of a new product and/or new business technology (COOPER; EDGETT; KLEINSCHMIDT, 1999; ROUSSEL; SAAD; ERICKSON, 1991). Larger companies usually use these practices, but we recognize the opportunity for SMEs to utilize them and contribute to Innovative green projects and their positive consequences (BOTKIN; KELLER, 2011).

The entrepreneurs from the companies of this work recognize this importance and the opportunity as a business. Although the theory indicates this possibility considering innovative and sustainable projects (SABINI *et al.*, 2019), this study of multiple cases showed that companies do not formally use project management and that project management is used intuitively. It seems to be related to the nature of companies, SMEs (ESKEROD; HUEMANN, 2013; SILVIUS *et al.*, 2012; TURNER; LEDWITH; KELLY, 2010). The entrepreneurs' concerns can be mitigated by adapting project management practices to the size and during companies' growth (TURNER; LEDWITH; KELLY, 2010), or the possibility of adopting more agile practices that are more agile collaborative and less bureaucratic.

Our study contributes to the management of sustainable innovation projects by pointing out the possibility and need to evaluate the use and adaptation of project management practices in SMEs. It contributes to the link between sustainability and project management, which is lacking in works that link the two areas of knowledge (MARTENS; CARVALHO, 2016) and reinforces the potential of using Project management practices in SMEs (TURNER; LEDWITH; KELLY, 2010).

6 CONCLUSIONS

This paper helps to clarify the potential and challenges of using project management tools and practices by SMEs dedicated to the development of innovative green fabric products. Businesses that work with green product innovation may miss the opportunity to incorporate formal project management into their daily lives. This is especially the case with SMEs, such as the companies in this study. According to the literature, adequate project management is essential for businesses that want to innovate. A company managing its projects well will drastically minimise difficulties in managing its innovations (BARNES, 1991).

This study has an inherent limitation in the multi-case study methodology. It is known that even though it is a study with multiple cases, it is not possible to have the desired scope. However, to compensate for this limitation, care was taken to triangulate the data, even with interviews as the primary data source. It is intended to evolve with this same research. The intention is to collect more interviews from the companies already selected and select other companies to participate in the study. The aim is to obtain a larger sample that allows more robust research.

As future recommendations, it is suggested that a quantitative survey be performed to confirm the constructs selected in the qualitative study. This will help ensure which constructs are appropriate for the proposed research and make it possible to offer a model that contemplates the use of project management in green innovation projects.

As practical results, this study contributes to the evidence that companies' managers and entrepreneurs can use by adapting project management tools and practices to improve their outcomes and sustainability. It also indicates the importance of professional associations and government actions to encourage and prepare entrepreneurs to use these project management practices effectively and adequately.

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Pre-consumption textile waste management in the clothing industry in Teresina/PI

Gerenciamento dos resíduos têxteis pré-consumo da indústria de confecção do vestuário em Teresina/PI

Simone Ferreira de Albuquerque [1]

Maria do Socorro Ferreira dos Santos [2]

José Machado Moita Neto [3]

[1] Master in Brasilian History, PhD Candidate in Environment and Development, Professor, Universidade Federal do Piauí – UFPI, Teresina, PI, Brazil
E-mail: simonefalbuquerque@ufpi.edu.br

[2] PhD in Chemical Engineering, Professor, Universidade Federal do Piauí – UFPI, Teresina, PI, Brazil
E-mail: socorroferreira@ufpi.edu.br

[3] PhD in Chemistry, Professor, Universidade Federal do Piauí – UFPI, Teresina, PI, Brazil
E-mail: jmoita@ufpi.edu.br

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ARTICLE – VARIA

ABSTRACT

The garment industry stands out as the second-largest employer in the manufacturing industry, but it is singled out for environmentally and socially unsustainable practices. In this study, managers of ten companies in Teresina (Piauí State, Brazil) were interviewed to investigate textile waste management methods and instruments and the difficulties and challenges found in management. Methodologically, it was used bibliographical, exploratory, documental and case study research. The research instruments were the questionnaire, direct observation and interview. Data were assessed through content analysis. The results show that part of the production-related waste is donated to manufacture rugs and fuxico, discarded for everyday collection. The conclusion we came across is that the clothing industry in Teresina lacks better management of its production process to generate less waste. When it is not possible to reuse it, dispose of it properly.

Keywords: Textile Waste Management. Garment Industry. Environment. Disposal Methods. Teresina.

RESUMO

A indústria de confecção do vestuário destaca-se como segundo maior empregador da indústria de transformação, mas é apontada por práticas ambiental e socialmente insustentáveis. Neste estudo, foram realizadas entrevistas com gestores de dez empresas do ramo em Teresina (Piauí), cujo objetivo foi investigar os métodos e instrumentos de gestão dos resíduos têxteis, além das dificuldades e desafios

encontrados nessa gestão. Metodologicamente, utilizou-se a pesquisa bibliográfica, exploratória, documental e o estudo de caso cujos instrumentos de pesquisa foram o questionário, a observação direta e a entrevista. Os dados foram avaliados por meio da análise de conteúdo e os resultados apontam que parte dos resíduos têxteis é doada para a confecção de tapetes e fuxico, enquanto outra parte é descartada para a coleta comum. Conclui-se que a indústria de confecção do vestuário em Teresina carece de um melhor gerenciamento do seu processo produtivo de forma a gerar menos resíduos e, quando não for possível reutilizá-los, descartá-los de forma adequada.

Palavras-chave: Gestão de Resíduos Têxteis. Indústria de Confecção do Vestuário. Meio Ambiente. Métodos de Descarte. Teresina.

1 INTRODUCTION

The Apparel Industry is considered one of the most crucial manufacturing industry sectors because it promotes employment and income worldwide. However, it is part of a linear production and business model based on temporary trends (INDUSTRY OF ALL NATIONS, 2017). Because of this, it is one of the most polluting industries in the world, being responsible for impacts throughout its production chain, from planting (with the extraction of raw materials, use of water, and energy) to manufacturing (with the help of labour, energy, waste), and in the after consumption, with products that are soon discarded by the consumer (ELLEN MACARTHUR FOUNDATION, 2013). Thus, it becomes clear that the clothing industry prioritises the economic sector, not regarding environmental and social issues, going against the Circular Economy and Sustainable Consumption. It is, therefore, the effect that Carson (1969) called human assaults on the environment. Among several factors, this is because this industry globally uses around 98 million tons of non-renewable resources per year and because only 13% of the materials used in clothing production are reused (HERRMANN *et al*., 2017).

Another critical factor is that this sector is dominated by standardised mass production, which uses low-cost material and labour to provide cheap clothes produced in significant volume, and is sensitive to industrialised countries trends (FLETCHER, 2010). Allied to this situation, inadequate working conditions are evident, which constitute a serious problem in the sector as forced labour or labour analogous to slavery and child labour are constant and must be combated (VEIGA; GALHERA, 2017). In that sense, the National Confederation of Industry (in Brazil) (2017) points to the need to monitor labour relations. It emphasises that there must be tools capable of detecting exhausting working hours, forced labour, debt bondage, hiring irregular foreign labour and child labour. In addition, it informs that it is a relevant theme in the manufacturing segment since they are fragmented companies, making the supervision by the public authorities a difficult process.

Given this, the importance of Brazil in this scenario is highlighted, as the country appears as the fourth largest clothing's producer in the world, with the women's fashion segment being the most representative. Additionally, the country has a complete textile chain globally, as it is self-sufficient from the planting and production of fibres to the ready product retail. Worldwide, Brazil is characterised as the fourth largest fashion consumer, the sixth-largest textile industry, the second-largest producer of denim and the third-largest producer of knitwear (ABIT, 2019). It is also considered the second largest employer in the manufacturing industry, generating employment and income and accounting for 16.7% of jobs (ABIT, 2019), with approximately 1.5 million direct jobs and about eight million indirect jobs (ABIT, 2017) however, as it is the second industry that most impacts the environment (INDUSTRY OF ALL NATIONS, 2017), its practices should be reviewed to make them more sustainable over time.

The fast-fashion production model, with quickly, cheaply, and low-quality manufacturing and marketing, facilitates the disposal and/or replacement of products by the consumer (HIRSCHER, 2018); it is linked to the linear production model, which causes several environmental and social damages (SOUZA, 2017), aggravating the waste problem (NIINIMAKI, 2015). In this industry production process, the most

significant volume of manufacturing waste generation is in the cutting sector (pre-consumption waste), which, in many cases, is carried out without planning as a result of decisions taken in the creation sector. At this stage, several factors related to the acquisition of fabrics deserve to be observed for the manufacturing waste better use and reduction, such as the width, the composition, the structure of the fabric, the print, the design of the pieces and consequently the modelling. This pre-consumer waste (or clean waste) comes from the cutting and sewing step (shavings) as well as from textile samples, end-of-roll textiles, damaged textiles, unsold textiles, clothing waste, sampling yards and clothing sample waste (REDRESS, 2017).

Particular attention should be given to shavings, defined by Cuc and Tripa (2018) as gaps and non-usable areas between the moulds of garments when spread over the layers for scratching and cutting, as approximately 170,000 tons of textile and clothing scraps are generated per year. From this amount, 80% is illegally disposed of in landfills. Regarding clothing items (clothing waste), it is estimated that more than 150 million items/year have no defined destination and end up being stocked, discarded or destined for bazaars (BARUQUE-RAMOS *et al*., 2017). There is also an estimate that 50% to 75% of the pieces are sold from the collections, with the rest destined for promotions, and about 7%, donated, crushed, incinerated or deposited in landfills (IEMI, 2015). Only 1% is recycled into new products after the end of the life cycle (AGENDA MODA BRASIL, 2019).

As the picture presented, the garment manufacturing industry must consider not only the improvement of its production processes with the implementation of clean technology and energy efficiency but also the management of these wastes as an essential condition for the preservation of natural resources and the control of the manufacturing waste to get a cleaner and more efficient production. The control of the production-related waste must be considered throughout the entire chain. Specifically, in the garment manufacturing industry, this control should start since the creative process, including the correct choice of raw material, adequate rest of the fabric to prevent further shrinkage, well-thought-out modelling to avoid excessive use of curves, fitting with the largest possible use, the definition of the grid with suitable combinations in the same fitting plane, among others (DEBASTIANI; MACHADO, 2012).

It is noteworthy that the clothing industry has no control over the disposal of production-related post-consumer waste. These are commonly used as donations to family, friends and needy people or reused in the form of rags for household cleaning (MORGAN; BIRTWISTLE, 2009). However, a large part ends up in municipal solid waste streams, landfilled without the possibility of practical use (NENCKOVÁ; PECAKOVÁ; SAUER, 2019). It is estimated that more than 70% of the valuable life of discarded clothing remains at the time of disposal (SATCOL, 2019). That said, the treatment of these wastes, which are mostly sent to landfills and/or incinerated (TOJO *et al*., 2012), contributing to GHG emissions and soil contamination (HU *et al*., 2018), should be regarded when it comes to discussing the sustainability of the sector. The environmental impacts caused by conventional methods can be reduced by developing new technologies for recovering and reusing textiles to meet circular businesses' current and future needs (BETON *et al*., 2014).

Thereby, some strategies are pointed out in the literature to reduce the volume of these residues as much as possible. Recycling is one of them, although its rate is shallow in this type of industry. The fabric can be transformed into fibres through mechanical or chemical processes (NORUP *et al*., 2019), giving rise to new fabrics, and converted into energy or heat (ÇAY et al., 2018), and is used in the construction industry, in the production of material for acoustic and thermal insulation (ISLAN; BHAT, 2019), among others. El Hagar (2009) points to Reverse Logistics and a circular production chain, characterised as a restorative and regenerative economy to maintain products and components with maximum useful life. However, these methods are complicated to be adapted to the garment manufacturing industry, which are primarily individual microenterprises and individual microenterprises (called MEI) and have no capital to invest in technologies. Thus, proper planning and management are the most viable way to reduce the volume of production-related waste, making it essential to prevent negative impacts on the environment and reduce financial costs. Thus, Nenchková, Pecakovà and Sauer (2019) consider

that consumer disposal behaviours are a critical factor in influencing the impact on the environment. A consumer aware of the environmental cause must consider how they use, care for and dispose of their clothes (RISSANEN, 2013).

In Piauí, the garment manufacturing industry is the fourth fastest economically growing sector in the state, with the capital, Teresina, standing out as the largest producer (SEMDEC, 2017). As we can see in this scenario, and given the importance of this industry for economic development and the preservation and/or conservation of the environment, this work aimed to carry out exploratory research in individual clothing microenterprises (called MEI) and microenterprises in Teresina, to investigate the generation of produced-related textile waste (type of waste, volume and disposal methods), management methods and instruments (practices and investments), in addition to the difficulties and challenges encountered in management and its final destination.

2 MATERIAL AND METHOD

The criterion to select the companies visited was registering their main activity with the Brazilian Federal Revenue. We chose industries registered with CNAE, the National Classification of Economic Activities – 1412-6/01 (manufacture of garments[2], except underwear and tailor-made garments) as they represent the largest number of industries in the city of Teresina. This classification is adopted by the National Statistical System in Brazil (coordinated by the Brazilian Institute of Geography and Statistics[3]) and by federal, state and municipal organs that manage administrative records and other institutions in the country. In addition to the National Classification of Economic Activities, the speed with which the company responded to the request to participate in the survey was considered since there was the possibility of a lockdown in the companies due to the Pandemic caused by the SARS Covid-19, which suspended activities with direct contact between people. The survey was conducted from January to March 2021.

Methodologically, bibliographical, exploratory and documental research was developed, followed by field research with visits to ten companies (individual microenterprise and microenterprise), configuring itself as a case study centred on the clothing manufacturing industry of the city Teresina as the object of study. The data collection instruments were the guided questionnaire (which conducted the interviews and observation), direct observation and interviews with managers and those responsible for each sector (totalling 32 interviews). The data were analysed through content analysis. According to Rúdio (2015), observation as a research instrument is used to obtain specific information from reality, as it is a way of seeing, examining and knowing the phenomena. The interview aims to raise problems and collect initial data for a survey, allowing that the respondent raises questions that have not been considered yet by the researcher (SOMMER; SOMMER, 2002).

The case study was chosen as the method suitable for the investigation of a contemporary phenomenon within its proper context, being able to explore real-life situations whose limits are not clearly defined; preserve the unitary character of the studied object; describe the case of the context in which the investigation is being carried out; formulate hypotheses or develop theories; and explain the causal variables of a given phenomenon in situations that do not allow the use of surveys and experiments (YIN, 2012).

During the visits, all the stages of the production process were monitored. The questionnaire guided the interviews and observation. Its elaboration was based on the bibliographic research carried out in this work and was divided into three parts: the first part was focused on the creative sector to identify if the product was conceived regarding sustainability issues. The second part was aimed at identifying the type and nature of the production-related textile waste (fabric scraps, end-of-roll scraps, finished garments), in addition to the volume and final disposal. And the third part was exclusively oriented towards waste management (sustainability practices and investments, sustainable planning and projects, investments, management difficulties).

This method was applied to deepen the knowledge in production-related waste management in the garment manufacturing industry to develop more effective practices. The activities observed were creative process (product design), acquisition of raw materials (suppliers) and the production process (electricity consumption, water consumption, waste generation - fabric trimmings, fabric scraps, stranded pieces, paper, trim, hardware etc.). The production, management, volume and final disposal of waste were the target of the research. It is noteworthy that the research addresses the pre-consumer production-related waste of the studied industry. Data were evaluated through content analysis and carried out in three stages: pre-analysis, material exploration and treatment of the obtained results, followed by an interpretation (BARDIN, 2015). With the content of the interviews and observation, the findings in the communication process were described.

3 ANALYSIS AND DISCUSSION OF RESULTS

During the process of bibliographical and documental research, it was noticed that the local statistical data referring to the manufacturing centre in Teresina diverge from the data provided by federal agencies organs. Data Sebrae (2020) reports that the state of Piauí has 1,085 companies (registered with Cnae – 1412/6-01), mostly individual micro-enterprises (659) and microenterprises (384) and Teresina represents 67% (727) of this amount: individual micro-enterprises (425), microenterprises (267), EPP (small businesses) (20) and Other (invoicing above 4.8 million/year) (15) confirming data from the Brazilian Federal Revenue, which informs that Teresina has a clothing manufacturer hub formed by 727 companies National Confederation of Industry – 1412/6-01. Field research indicates that many of them are closed. However, remain active with the Federal Revenue, and many are unable to officially terminate their activities due to a lack of financial resources to meet debts, mostly taxes and rates.

Regarding data provided by local agencies, these are scarce. The action of the Brazilian Micro and Small Business Support Service in Piauí and the Federation of Industries of the State of Piauí was identified with these companies in promoting consultancy and support for the sector's development, but not provide up-to-date and publicly available statistical data. Teresina's city hall, through the Municipal Planning Secretariat (Semplan) and the Municipal Economic Development Secretariat (Semdec), hired Cluster Consulting Teresina to run a Cluster Competitiveness Program with companies in the city based on the development of health services clusters, apparel, fashion and education services, in addition to promoting the training of the city hall and partner institutions (Sebrae-PI, Fiepi, Banco do Nordeste – BNB) on competitiveness issues and clusters.

Thus, local data provided by Cluster Consulting (2017) point to a cluster formed by 216 companies (data that do not specify the main activity of the establishment), which employ approximately 2.268 people and are distributed in various niches: casual fashion (45%), jeans (30%), activewear and underwear/beachwear (5%), uniforms (10%) and party/tailored fashion (10%), niches which have the production of approximately 6 million pieces in 2018, and sales of R$ 175 million.

Given data obtained through bibliographic and documentary research, the importance of the sector and this research for the local economy was affirmed. Thus, exploratory and field investigation was started, and during the interviews, it was identified right from the start that there is no concern or orientation towards sustainable development. For Desireé (2019), the applicability of the guidelines for sustainable development and social responsibility at all stages of the production chain is of fundamental importance to combat environmental damage caused by the fashion industry.

The results confirm the findings of Prieto-Sandoval *et al.* (2018), who claim that the clothing Industry still follows a linear production model: extraction – transformation – disposal, producing tons of waste and pollutants, ignoring the limits of nature and damage to society. Pinheiro (2018) reports that sustainable development has been a concern for the management of the garment manufacturing industry since the 1960s, in line with the statement of the National Confederation of Industry – CNI

(2017), which informs that in the last five years, the companies in Brazil have shown a more significant concern with sustainability through projects and initiatives that aim to improve the environmental, social and economic aspects of their processes.

The companies visited show a developing knowledge about the subject and even less about the legislation to which they are subject. It was also identified that its target audience is not a conscious consumer. It does not require sustainable attitudes from the company. The inspections to which they are subject are only directed towards the labour sector. This set of components divert the manager from environmental-oriented management. These findings reinforce the data from Sebrae - SP (BRAZILIAN NETWORK OF INTERNATIONAL BUSINESS CENTERS – RBCIN, SEBRAE, CNI, 2016), which states that there is a general lack of knowledge about environmental standards or regulations on behalf of managers that come from the garment manufacturing industry, which, for the most part, think they have no obligations to the environment. This information results from a survey carried out in the state of São Paulo, the largest national clothing centre, which asked questions about Regulations and Norms, Labor Area and Material Disposal. The results of Sebrae - SP also showed that companies are unaware of the fashion sector's environmental regulations. In addition, they declared that they did not have any help from any institution that would inform and point out what is necessary to adapt to the required standards.

During the visits, observing the production process, it was possible to identify that the garment manufacturing industry produces several types of solid waste: paper, cardboard, PVC and cardboard tubes, plastic spools, thread, needles, plastic and cardboard packaging and textile waste (splits and scraps at the end of the roll), whose destination must be adequate due to its volume, composition and degradation time. Among the listed residues, textile wastes are highlighted for their volume and final disposal. The results agree with what Alencar and Assis (2012) cite as solid production-related wastes from the garment industry: scraps, trimmings, defective garments, powder from the overlock machine, plastic spools, cardboard and PVC tubes, needles, lines, lamps, lubricating oil containers, drums of liquid chemicals and dirty tows. Based on this, it can be inferred that it is necessary to have control and inspection in the production and destination of these residues.

Some local companies are already concerned about the control of chips produced in the cutting sector, even though they are more focused on saving raw material due to financial and non-environmental terms and focusing more on the slotting industry (use of software), with no planning in the creative sector that aims to reduce the amount of waste produced at the end of the process. Nikolau, Tsalis and Evangelinos (2019) explain that the sustainable practices of the companies must be directed towards the economic investment in a practical way while at the same time setting environmental and social goals that guarantee the protection of the natural environment and justice.

One company interviewed mentioned concern with the modelling of the piece still in the creation sector, even though it was more aimed at the economic (time and amount of raw material) than sustainable factor, but which contributes to the reduction of waste in the cutting sector going in the same direction proposed by the conscious modelling method: a way to adapt the mould so that the result has the lowest possible waste rate (BINELLI, 2020). The more curved shapes and irregularities in the part modelling, the more residue it will generate (WONG *et al.*, 2013). Alencar *et al.* (2015) report that, due to the shape of the moulds that do not provide a perfect fit, waste can reach up to 30% of the fabric. It is already proven that conscious modelling results in a superior use of the fabric (BINELLI, 2020). Still, the designer must have a good knowledge of modelling and creativity to attract its customer. In practice, not all designers have this vision of modelling in the creative process, as this practice is not built in most fashion design courses, which can be observed in the curriculum.

The selection of raw materials and trims is essential for the sustainability of the processes as for recycling. It should always be the first choice for managers and professionals responsible for the creative sector, which, consequently, will interfere in the final volume of production-related waste. It is essential to consider that biodegradable raw material, with biopolymers, organic, certified, recycled,

regenerated, compostable and/or traceability will always be the first choice. In none of the companies visited in Teresina was there an option for biodegradable raw material, as managers consider its cost to be between 20% and 30% higher than the cost of standard raw material, and the result is an increase in the final cost of their product, making its commercialisation unfeasible due to the competition. Bastian and Rocco (2009) point out that when this type of raw material cannot be used, adopting those whose suppliers offer information about the kinds of substances applied to their products is always the next choice. However, this concern with its suppliers' ethics has not been observed in the companies visited.

It is noteworthy that the way the fabric is constructed deserves to be considered, as it can limit the positioning of the moulds due to the fabric weft, leading to a more significant generation of chips and waste. The width of the fabric directly interferes with the volume of waste produced in the cutting sector. And certain types of prints also present themselves as limiting factors for the positioning of the moulds. It was observed that most of the companies visited do not do previous planning and do not consider the structure of the fabric construction. However, some avoid using fabrics with certain prints that may limit the positioning of the patterns, especially fabrics with shine, stripes and vertical stripes. Still, the fact is essentially due to economic factors. Others, however, don't use it often but do not avoid its use if the print is within the trends or the collection's theme.

As for the choice of accessories and trim, one must keep in mind their composition and be aware that they make it difficult or impossible to recycle parts after their disposal. It is suggested that the designer, before starting any collection, check the available material in the stock to include its use in the new pieces and, in addition, it is recommended that planning be carried out to avoid unnecessary purchases, which would generate waste in addition to economic and environmental damage.

It was found that, during the pandemic caused by Sars Cov-19, the companies started to consider the use of raw material and supplies available in stock due to the difficulty of finding raw material available on the market and to the high prices charged, awakening to the need to control your warehouse so that leftovers are avoided and/or reused. They started to apply tinting techniques for trims to achieve the trend colour used in new collections. But, again, one can see the predominance of the economic factor in detriment of the sustainable one, but somehow it contributes to the sustainability of the process. In more than 50% of the companies, inventories ran out and stocked finished parts, which led the management to rethink how to buy and use the raw material.

Regarding the composition of trims, the research did not find any report that demonstrated knowledge and/or interest in its composition, nor in the use of ornaments of different designs in the same piece that could somehow hinder the post product recycling.

Considering the importance of the layering sector, an operation in which the fabric is placed in layers on the cutting table and the moulds, manual and mechanical layers were identified during the visits. In the industries visited in Teresina, the use of manual spread, with support and a manual trolley with selvedge aligner can be seen, the most common being the spread with a selvedge aligner, indicated in this work as the most suitable for the size of the companies visited.

As it is common for industries to make the same model in the same fabric, varying only the colour, we find many variations in the width of the same fabric from the same manufacturer in the layering sector. It is noticed that certain manufacturers do not have this quality control. Different colours have different widths for the same product, which compromises production yield and generates a waste that could be minimised. In the deposit and risk sector, the companies visited already use computerised deposits in their entirety. This method increases precision, maximises fabric use, reduces risk realisation time, minimises waste, calculates fabric use efficiency simultaneously, and increases profit (PURANIK; JAIN, 2017).

The literature points to the cutting sector as the responsible for the largest volume of waste related-production in companies. However, it is noteworthy that the fact occurs due to the decisions taken by the creation sector. The reduction of waste related-production must be considered already in that

sector with differentiated strategies in developing collections. When this is not possible, the focus can be directed towards reusing and recycling this waste. Also noteworthy is the waste that reaches the cutting sector both in environmental ethics and economic perspectives. Thus, one must meet the waste management strategies to avoid waste. However, what is observed is that in the companies visited, there is no planning of the creation sector aimed at reducing the volume of garbage that is concentrated in the cutting industry, corroborating with Enez and Kipoz (2020), who pointed out that 36.7% of the companies do not make efforts to eliminate waste in the cutting and sewing sector.

The textile residues found in the research were shavings in the cutting sector, fabric scraps that remain in the rolls, parts with defects, parts that were not well accepted and that, even so, remain in stock. Part of the shavings is destined for donation to charities or everyday individuals to promote the making of rugs and gossip. Another part, the smaller ones, is discarded for everyday municipal collection, having the sanitary landfill as the destination. The recycling of this waste was not identified at the time of the survey by the interviewed companies. Still, some reported that there was a time when a large mattress industry in the city received and/or collected this waste, which went through different processes and was used as a filling for mattresses, but that, at the time of the research, they were no longer carrying out this collection. For Leal Filho *et al.* (2019) and Islam and Bhat (2019), the clothing sector is a significant generator of the waste and a producer of raw material losses due to excess production, and they, in turn, suggest that recycling and reuse are necessary as they bring numerous benefits to the environment.

It is noteworthy that the research did not identify the amount of waste produced per collection nor the amount destined for the landfill, as the visit time did not allow for this observation because several days are needed to make a collection. The visit was limited to a shift due to the short period available by the manager to monitor the researchers and the increase in Sars-Covid cases during the period of the survey. The scraps that are characterised as end-of-roll scraps are, for the most part, sold to the employees themselves. Defective parts and those that were not well accepted are sold at the end of the year at promotional fairs at cost price. It is recognised that it is difficult to correctly dispose of textile waste, especially shavings since the city does not have a specific collection for this type of waste or cooperatives that can recycle or reuse them.

Most of the companies visited use outsourcing in search of increasingly reduced and competitive prices in the assembly sector and outsourced between 50% and 70% of the assembly of their parts. Outsourcing occurs with seamstresses, mostly former employees of a company, who work from home, where they are divided between sewing work and household chores, in line with the information provided by Agenda Moda Brasil (2019), which claims to have an impact on outsourcing in the sector (subcontracting) where the risk of severe violations of human and labour rights is high. Leite, Silva and Guimarães (2017) complement by informing that the assembly of the pieces is almost no longer carried out in Europe and North America, and it is being restricted to Latin American and South Asian countries.

4 FINAL CONSIDERATIONS

Clothing industry individual micro-enterprises (MEI) and micro-enterprises (ME) visited in Teresina recognise the production-related waste as environmental damage but do not promote any intervention in the production process that could reduce the amount of waste produced.

Some types of residues were identified and, among them, the emphasis in volume is on shavings. Part of these shavings are donated to make rugs, gossip, and charities, and another is discarded for everyday collection. One of the research limitations was the impossibility of quantifying the volume produced monthly and the volume that is donated or discarded. Also noteworthy are the limitations and difficulties found imposed by the Covid-19 Pandemic, which limited the number of visits necessary for the research.

Based on the results, it can be deduced that the companies' managers visited do not commit to environmental protection practices. The vast majority recognises sustainability only in the control of waste in the cutting sector. They recognise the need for a professional specialising in the subject but do not have financial reserves for this purpose. For them, sustainability is a market niche that does not attract its target audience. Therefore, it is not within their mission.

The individual microenterprises and microenterprises represent the reality in Teresina and the Brazilian context, pointing out the need for new studies that indicate effective ways to implement environmental and social sustainability practices at low costs suitable to the reality of these companies.

NOTES

1 | The work will be part of the annals of X Enanppas.

2 | Refers to tracksuits, shorts, blazers, blouses, sports and social shirts, long pants, t-shirts, capes, coats, costumes, jackets, suits, skirts, dresses, sets, overcoats, clothes for practice sports and beachwear (CNAE, 2010). Available at: https://concla.ibge.gov.br/busca-online-cnae.html?subclasse=1412601&tipo=cnae&view=subclasse. Accessed on: nov. 2021.

3 | Brazilian legislation (law 6183, of 12/11/74) gives IBGE the responsibility for coordinating the national statistical system.

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Gerenciamento dos resíduos têxteis pré-consumo da indústria de confecção do vestuário em Teresina/PI

Pre-consumption textile waste management in the clothing industry in Teresina/PI

Simone Ferreira de Albuquerque [1]

Maria do Socorro Ferreira dos Santos [2]

José Machado Moita Neto [3]

[1] Mestrado em História do Brasil, Doutoranda em Desenvolvimento e Meio Ambiente, Professora, Universidade Federal do Piauí, Teresina, PI, Brasil
E-mail: simonefalbuquerque@ufpi.edu.br

[2] Doutorado em Engenharia Química, Professora, Universidade Federal do Piauí, Teresina, PI, Brasil
E-mail: socorroferreira@ufpi.edu.br

[3] Doutorado em Química, Professor, Universidade Federal do Piauí, Teresina, PI, Brasil
E-mail: jmoita@ufpi.edu.br

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RESUMO

A indústria de confecção do vestuário destaca-se como segundo maior empregador da indústria de transformação, mas é apontada por práticas ambiental e socialmente insustentáveis. Neste estudo, foram realizadas entrevistas com gestores de dez empresas do ramo em Teresina (Piauí), cujo objetivo foi investigar os métodos e instrumentos de gestão dos resíduos têxteis, além das dificuldades e desafios encontrados nessa gestão. Metodologicamente, utilizou-se a pesquisa bibliográfica, exploratória, documental e o estudo de caso cujos instrumentos de pesquisa foram o questionário, a observação direta e a entrevista. Os dados foram avaliados por meio da análise de conteúdo e os resultados apontam que parte dos resíduos têxteis é doada para a confecção de tapetes e fuxico, enquanto outra parte é descartada para a coleta comum. Conclui-se que a indústria de confecção do vestuário em Teresina carece de um melhor gerenciamento do seu processo produtivo de forma a gerar menos resíduos e, quando não for possível reutilizá-los, descartá-los de forma adequada.

Palavras-chave: Gestão de Resíduos Têxteis. Indústria de Confecção do Vestuário. Meio Ambiente. Métodos de Descarte. Teresina.

ABSTRACT

The garment industry stands out as the second-largest employer in the manufacturing industry, but it is singled out for environmentally and socially unsustainable practices. In this study, managers of ten

companies in Teresina (Piauí State, Brazil) were interviewed to investigate textile waste management methods and instruments and the difficulties and challenges found in management. Methodologically, it was used bibliographical, exploratory, documental and case study research. The research instruments were the questionnaire, direct observation and interview. Data were assessed through content analysis. The results show that part of the production-related waste is donated to manufacture rugs and fuxico, discarded for everyday collection. The conclusion we came across is that the clothing industry in Teresina lacks better management of its production process to generate less waste. When it is not possible to reuse it, dispose of it properly.

Keywords: *Textile Waste Management. Garment Industry. Environment. Disposal Methods. Teresina.*

1 INTRODUÇÃO

A Indústria de Confecção do Vestuário é considerada um dos setores da indústria de transformação mais importantes, por gerar emprego e renda em todo o mundo. Porém, se insere em um modelo de produção linear e de negócios baseado em tendências efêmeras (INDUSTRY OF ALL NATIONS, 2017). Devido a isso, é uma das indústrias mais poluentes no mundo, responsável por impactos ao longo de toda a sua cadeia produtiva, desde o plantio (com a extração de matéria-prima, uso de água, e de energia), à fabricação (com o uso de mão de obra, energia e resíduos), e no pós-consumo, com produtos que são logo descartados pelo consumidor (ELLEN MACARTHUR FOUNDATION, 2013). Desse modo, vê-se que a Indústria de Confecção do Vestuário prioriza o setor econômico, não considerando os aspectos ambientais e sociais, indo contra a Economia Circular e o Consumo Sustentável. Trata-se, portanto, do efeito que Carson (1969) denominou de assaltos do ser humano contra o meio ambiente. Entre vários fatores, isso ocorre porque essa indústria, globalmente, utiliza cerca de 98 milhões de toneladas de recursos não renováveis por ano, e porque apenas 13% dos materiais utilizados na produção das roupas são reutilizados (HERRMANN *et al.*, 2017).

Um outro fator muito importante é que esse setor é dominado pela produção padronizada em massa, que utiliza material e mão de obra de baixo custo para fornecer roupas baratas, em quantidade, e sensíveis às tendências aos países industrializados (FLETCHER, 2010). Aliado à essa situação, evidenciam-se as condições inadequadas de trabalho, que se configuram como um grave problema do setor, pois o trabalho forçado ou análogo à escravidão e o trabalho infantil são constantes, devendo ser combatidos (VEIGA; GALHERA, 2017). Nesse sentido, a Confederação Nacional da Indústria – CNI (2017) aponta para a necessidade de um monitoramento das relações de trabalho e salienta que devem existir ferramentas capazes de detectar jornadas exaustivas, trabalho forçado, servidão por dívida, contratação de trabalho estrangeiro irregular e o trabalho infantil. Além disso, informa que é um tema de relevância, no segmento de confecção, uma vez que são empresas fragmentadas, dificultando a fiscalização pelo poder público.

Diante do exposto, destaca-se a importância do Brasil nesse cenário, pois o país aparece como o quarto maior produtor mundial de peças do vestuário, sendo o segmento de moda feminino o mais representativo. Adicionalmente, o país possui a cadeia têxtil mais completa do mundo, visto que é autossuficiente desde a plantação e produção de fibras até o varejo do produto acabado. Mundialmente, o Brasil se caracteriza como o quarto maior consumidor de moda, a sexta maior indústria têxtil, o segundo maior produtor de denim e o terceiro de malhas (ABIT, 2019). Também é considerado o segundo maior empregador da indústria de transformação, gerando emprego e renda, e sendo responsável por 16,7% dos empregos dessa indústria (ABIT, 2019) com aproximadamente 1,5 milhão de empregos diretos e cerca de oito milhões indiretos (ABIT, 2017). Contudo, por ser a segunda indústria que mais impacta/degrada o meio ambiente (INDUSTRY OF ALL NATIONS, 2017), suas práticas devem ser revistas de modo a torná-las mais sustentáveis ao longo do tempo.

O modelo de produção do *fast fashion*, com a fabricação e comercialização de forma rápida, barata, e de baixa qualidade, que facilita o descarte e/ou a substituição dos produtos por parte do consumidor

(HIRSCHER, 2018), é ligado a esse modelo de produção linear que causa diversos danos ambientais e sociais (SOUZA, 2017), agravando o problema dos resíduos (NIINIMAKI, 2015). No processo produtivo dessa indústria, o maior volume de geração de resíduos está no setor de corte (resíduo pré-consumo) que, em inúmeros casos, é realizado sem planejamento, como consequência de decisões tomadas ainda no setor de criação. Nessa etapa, vários fatores merecem ser observados na aquisição de tecidos para melhor aproveitamento e redução do resíduo produzido, tais como a largura, a composição, a estrutura do tecido, a estampa, o *design* das peças e, consequentemente, sua modelagem. Esse resíduo pré-consumo (ou resíduo limpo), além de ser proveniente da etapa de corte e costura (aparas), também provém de amostras têxteis, têxteis de fim de rolo, têxteis danificados, têxteis não vendidos, resíduos de roupas, resíduos de jardas de amostragem e resíduos de amostras de roupas (REDRESS, 2017).

Especial atenção deve ser dada às aparas, definidas por Cuc e Tripa (2018) como as lacunas e as áreas não utilizáveis entre os moldes das peças do vestuário quando estendidas sobre o enfesto para o risco e o corte, pois cerca de 170.000 toneladas de aparas têxteis e de confecção são geradas por ano. Desse montante, 80% é descartado irregularmente nos aterros sanitários. No que tange às peças de vestuário (resíduos de roupas), estima-se que mais de 150 milhões de peças/ano não tenham destino definido e acabem estocadas, descartadas ou destinadas a bazares (BARUQUE-RAMOS *et al.*, 2017). Há ainda a estimativa que das coleções vendem-se de 50% a 75% das peças, com o restante destinado a promoções, e cerca de 7% doado, triturado, incinerado ou depositado em aterros sanitários (IEMI, 2015). Apenas 1% é reciclado em novos produtos após o fim do ciclo de vida (AGENDA MODA BRASIL, 2019).

Diante do quadro apresentado, a indústria de confecção do vestuário há de considerar não só o aprimoramento de seus processos produtivos com a implementação de tecnologia limpa e eficiência energética, mas, também, o gerenciamento desses resíduos como condição essencial para a preservação dos recursos naturais e controle do desperdício de materiais para uma produção mais limpa e eficiente. O controle da produção dos resíduos há de ser considerado ao longo de toda a cadeia produtiva. Especificamente na indústria de confecção do vestuário, esse controle deve iniciar ainda no processo criativo, passando pela escolha correta da matéria-prima, descanso adequado do tecido para evitar encolhimento posterior, modelagens bem pensadas para evitar o uso excessivo de curvas, encaixe com o maior aproveitamento possível, definição da grade com combinações adequadas em um mesmo plano de encaixe, entre outros (DEBASTIANI; MACHADO, 2012).

Destaca-se que a indústria de confecção não tem nenhum controle sobre a forma de descarte do resíduo pós-consumo, e que este é comumente usado para doação para familiares, amigos e pessoas carentes, ou o reúso na forma de trapos para a limpeza doméstica (MORGAN; BIRTWISTLE, 2009). Porém, uma grande parte acaba nos fluxos de resíduos sólidos municipais, aterrados sem possibilidade de utilização efetiva (NENCKOVÁ; PECAKOVÁ; SAUER, 2019). Há estimativa de que mais de 70% da vida útil das peças de roupa descartadas permanece no momento do descarte (SATCOL, 2019). Posto isso, o tratamento desses resíduos, que em sua maioria é destinada ao aterro sanitário e/ou incinerados (TOJO *et al.*, 2012), contribuindo para as emissões de GEE e contaminação do solo (HU *et al*., 2018), deve ser melhor considerado ao se discutir a sustentabilidade do setor. Os impactos ambientais causados por métodos convencionais podem ser reduzidos com o desenvolvimento de novas tecnologias para recuperação e reutilização de têxteis de forma a atender às necessidades atuais e futuras de negócios circulares (BETON *et al*., 2014).

Nesse sentido, algumas estratégias são apontadas na literatura para reduzir ao máximo o volume desses resíduos. A reciclagem é uma delas, embora sua taxa seja extremamente baixa nesse tipo de indústria. O tecido pode ser transformado em fibras por meio de processos mecânicos ou químicos (NORUP *et al*., 2019), dando origem a novos tecidos, e convertidos em energia ou calor (ÇAY *et al*., 2018), e sendo usados na indústria da construção civil, na produção de material para isolamento acústico e térmico (ISLAN; BHAT, 2019), entre outros. El Hagar (2009) aponta para a Logística Reversa e para uma cadeia circular de produção, caracterizada como uma economia restaurativa e regenerativa com o objetivo de manter produtos e componentes com a vida útil máxima. Entretanto, esses métodos

são extremamente difíceis de ser adaptados para a indústria de confecção do vestuário, que, em sua maioria, são microempresas individuais (MEI) e microempresas (ME), sem capital para investir em tecnologias. Assim, o planejamento e o gerenciamento adequados são o caminho mais viável para reduzir o volume de resíduos produzidos, tornando-se essenciais para a prevenção de impactos negativos ao meio ambiente e para a redução dos custos. Nesse sentido, Nencková, Pecakovà e Sauer (2019) consideram que os comportamentos de descarte dos consumidores são um fator-chave para influenciar o impacto causado ao meio ambiente. Um consumidor sensibilizado com a causa ambiental deve considerar a forma como usa, cuida e descarta suas peças de roupa (RISSANEN, 2013).

No Piauí, a indústria de confecção do vestuário é o quarto setor que mais cresce economicamente no estado, destacando a capital, Teresina, como maior produtora (SEMDEC, 2017). Diante desse cenário, e dada a importância dessa indústria para o desenvolvimento econômico e para a preservação e/ou conservação do meio ambiente, este trabalho teve por objetivo realizar uma pesquisa exploratória nas MEIs e MEs de confecção do vestuário em Teresina, de forma a investigar a geração de resíduos têxteis produzidos (tipo de resíduo, volume e métodos de disposição), os métodos e os instrumentos de gerenciamento (práticas e investimentos), além das dificuldades e desafios encontrados na gestão e em seu destino final.

2 MATERIAL E MÉTODO

O critério para seleção das empresas visitadas foi o cadastro de sua atividade principal junto à Receita Federal brasileira. Optaram-se pelas indústrias cadastradas na Classificação Nacional de Atividades Econômicas (Cnae) 1412-6/01 (confecção de peças do vestuário[2], exceto roupas íntimas e as confeccionadas sob medida) por representarem o maior número de indústrias na cidade de Teresina. Essa classificação é adotada pelo Sistema Estatístico Nacional do Brasil (coordenado pelo IBGE[3]) e pelos órgãos federais, estaduais e municipais gestores de registros administrativos e demais instituições do país. Além da Cnae, levou-se em consideração a rapidez com que a empresa respondeu à solicitação de participação na pesquisa, uma vez que havia a possibilidade de um *lockdown* nas empresas em virtude da pandemia ocasionada pelo SARS Covid-19, que suspendeu atividades em que houvesse contato direto entre as pessoas. A pesquisa foi realizada no período de janeiro a março de 2021.

Metodologicamente, desenvolveu-se uma pesquisa bibliográfica, exploratória e documental seguida de pesquisa de campo com visita a dez empresas (microempresa individual e microempresa), configurando-se como um estudo de caso, tendo, como objeto de estudo, a indústria de confecção do vestuário da cidade de Teresina. Os instrumentos de coleta de dados foram o questionário orientado (que guiou as entrevistas e a observação), a observação direta e a entrevista com os gestores e com os responsáveis por cada setor (totalizando 32 entrevistas). Os dados foram analisados por meio da análise de conteúdo. Segundo Rúdio (2015), a observação, como instrumento de pesquisa, é utilizada para se obter determinada informação de uma realidade, pois trata-se de uma forma de se ver, examinar e conhecer os fenômenos. Já a entrevista, tem o objetivo de levantar problemas e coletar dados iniciais para uma pesquisa, permitindo, inclusive, que o entrevistado levante questões que não tenham sido consideradas pelo pesquisador (SOMMER; SOMMER, 2002).

Optou-se pelo estudo de caso por ser o método adequado para a investigação de um fenômeno contemporâneo dentro de seu contexto verídico, podendo-se explorar situações da vida real cujos limites não estão claramente definidos; preservar o caráter unitário do objeto estudado; descrever a situação do contexto em que está sendo feita a investigação; formular hipóteses ou desenvolver teorias; e explicar as variáveis causais de determinado fenômeno em situações que não possibilitam a utilização de levantamentos e experimentos (YIN, 2012).

Durante as visitas, foram acompanhadas todas as etapas do processo produtivo. O questionário direcionou as entrevistas e a observação. Sua elaboração foi baseada nas pesquisas bibliográficas

realizadas neste trabalho e foi dividido em três partes: a primeira parte estava voltada para o setor de criação, de forma a identificar se na concepção do produto já havia a preocupação com a sustentabilidade. A segunda parte foi direcionada para a identificação do tipo e da natureza do resíduo têxtil produzido (aparas de tecido, retalhos de fim de rolo e peças do vestuário acabadas), além da quantidade e da disposição final. E a terceira parte estava orientada exclusivamente para a gestão dos resíduos (práticas e investimentos na sustentabilidade, planejamento e projetos sustentáveis, investimentos e dificuldades de gerenciamento).

Esse método foi aplicado com o intuito de aprofundar os conhecimentos na gestão dos resíduos na indústria de confecção do vestuário, de modo a apontar um desenvolvimento de práticas mais efetivas. As atividades observadas foram: processo criativo (projeto do produto), aquisição de matéria-prima (fornecedores) e o processo produtivo (consumo de energia elétrica, consumo de água, geração de resíduos – aparas de tecidos, restos de tecidos, peças encalhadas, papel, aviamentos, ferragens, etc.). A produção, o gerenciamento, o volume e a disposição final dos resíduos foram o alvo da pesquisa. Destaca-se que esta aborda os resíduos pré-consumo da indústria estudada. Os dados foram avaliados por meio da Análise de Conteúdo e realizados em três etapas: pré-análise, exploração do material e tratamento dos resultados obtidos, seguidos de interpretação (BARDIN, 2015). De posse do conteúdo das entrevistas e da observação, buscou-se descrever os achados no processo de comunicação.

3 ANÁLISE E DISCUSSÃO DOS RESULTADOS

Ao longo do processo de pesquisa bibliográfica e documental, percebeu-se que os dados estatísticos locais referentes ao polo confeccionista de Teresina divergem dos dados fornecidos pelos órgãos federais. O DataSebrae (2020) informa que o estado do Piauí possui 1.085 empresas (cadastradas na CNAE 1412/6-01), sendo em sua maioria microempresas individuais (659) e microempresas (384), e Teresina representa 67% (727) desse montante: MEI (425), ME (267), EPP (empresas de pequeno porte) (20) e demais, com faturamento acima de 4,8 milhões/ano (15), confirmando os dados da Receita Federal brasileira que informa que Teresina possui um polo confeccionista formado por 727 empresas (CNAE 1412/6-01). A pesquisa de campo aponta que muitas delas encontram-se fechadas, embora ativas na Receita Federal, e muitas impossibilitadas de encerrar oficialmente suas atividades por falta de recursos financeiros para cumprir com dívidas, em sua maioria impostos e tributos.

Com relação aos dados fornecidos por órgãos locais, estes são escassos. Identificou-se a ação do Serviço Brasileiro de Apoio às Micro e Pequenas Empresas do Piauí (Sebrae – PI) e da Federação das Indústrias do Estado do Piauí (Fiepi) voltada para essas empresas por meio da promoção de consultorias e apoio ao desenvolvimento do setor, porém, não fornecem dados estatísticos atualizados e disponíveis publicamente. A Prefeitura Municipal de Teresina, por intermédio da Secretaria Municipal de Planejamento (Semplan) e da Secretaria Municipal de Desenvolvimento Econômico (Semdec), contratou a Cluster Consulting Teresina para executar um Programa de competitividade em *clusters* com as empresas da cidade a partir do desenvolvimento de *clusters* de serviços de saúde, confecção, moda e serviços de educação, além de promover a capacitação da prefeitura e instituições parceiras (Sebrae – PI, Fiepi e Banco do Nordeste – BNB) em temas de competitividade e *clusters*.

Assim, os dados locais, fornecidos pelo Cluster Consulting (2017), apontam um polo formado por cerca de 216 empresas (dados esses que não especificam a atividade principal do estabelecimento), que empregam aproximadamente 2.268 pessoas e que estão distribuídas em nichos variados: moda casual (45%), jeans (30%), moda *fitness* e moda íntima/banho (5%), uniformes (10%) e moda festa/sob medida (10%), nichos os quais contam com a produção aproximada de 6 milhões de peças, em 2018, e faturamento de R$ 175 milhões.

Diante dos dados obtidos por meio das pesquisas bibliográfica e documental, constatou-se a importância do setor e desta pesquisa para a economia local. Assim, foi dado início à pesquisa exploratória e de campo, em que, durante as entrevistas, foi identificado logo de início que não há a preocupação nem

um direcionamento ao desenvolvimento sustentável. Para Desireé (2019), a aplicabilidade das diretrizes do desenvolvimento sustentável e da responsabilidade social em todas as etapas da cadeia produtiva é de fundamental importância para se combater danos ambientais provocados pela indústria da moda.

Os resultados encontrados confirmam os achados de Prieto-Sandoval *et al*. (2018), que afirmam que a Indústria de Confecção do Vestuário ainda segue um modelo linear de produção: extração – transformação – descarte, produzindo toneladas de resíduos e de poluentes, ignorando os limites da natureza e os danos à sociedade. Já Pinheiro (2018) informa que o desenvolvimento sustentável se constitui em uma preocupação da gestão da indústria de confecção do vestuário desde a década de 1960 indo ao encontro da afirmação da Confederação Nacional da Indústria – CNI (2017) que informa que, no Brasil, nos últimos cinco anos, as empresas revelaram uma preocupação maior com a sustentabilidade por meio de projetos e iniciativas que visam melhorias nos aspectos ambientais, sociais e econômicos de seus processos.

As empresas visitadas exibem um conhecimento incipiente sobre o assunto e menos ainda sobre a legislação a qual estão sujeitas. Também se identificou que seu público-alvo não é um consumidor consciente, não exige das empresas atitudes sustentáveis e que as fiscalizações a que estão sujeitas estão direcionadas ao setor trabalhista. Esse conjunto de componentes desvia o gestor de uma gestão voltada ao ambiental. Esses achados reforçam os dados do Sebrae – SP (REDE BRASILEIRA DE CENTROS INTERNACIONAIS DE NEGÓCIOS – RBCIN; SEBRAE; CNI, 2016) que afirma haver um desconhecimento geral sobre normas ou regulamentações ambientais por parte dos gestores da indústria de confecção do vestuário, os quais, em sua maioria, pensam não ter obrigações com o meio ambiente. Essa informação resulta de uma pesquisa realizada no estado de São Paulo, maior polo confeccionista nacional, na qual se questionou sobre a Regulamentação e Normas, Área Trabalhista e Descarte de Material. Os resultados do Sebrae – SP também evidenciaram que as empresas desconhecem as normatizações ambientais do setor da moda e, além disso, declararam não ter auxílio de nenhuma instituição que informe e/ou aponte o que é necessário para se adequar às normas exigidas.

Durante as visitas, observando o processo produtivo, foi possível identificar que a indústria de confecção do vestuário produz diversos tipos de resíduos sólidos: papel, papelão, tubos de PVC e de papelão, carretéis plásticos, linhas, agulhas, embalagens de plástico e papelão, e resíduos têxteis (aparas e retalhos de fim de rolo), cujo destino final deve ser adequado ao seu volume, composição e tempo de degradação. Entre os resíduos listados, os resíduos têxteis ganham destaque por seu volume e disposição final. Os resultados vão ao encontro do que Alencar e Assis (2012) citam como resíduos sólidos da indústria de confecção do vestuário: retalhos, aparas, peças do vestuário com defeito, pó da máquina de overloque, carretéis plásticos, tubos de papelão e PVC, agulhas, linhas, lâmpadas, embalagens de óleo lubrificante, bombonas de produtos químicos líquidos e estopas sujas. Com base nisso, pode-se inferir que o controle e a fiscalização na produção e destino desses resíduos são necessários.

Percebe-se que as empresas locais já exibem uma preocupação quanto ao controle das aparas produzidas no setor de corte, muito embora se faça mais objetivando a economia da matéria-prima em termos financeiros e não ambientais, e tenha seu foco mais direcionado para o setor de encaixe (uso de *softwares*), não havendo nenhum planejamento no setor de criação que objetive a redução da quantidade de resíduos produzidos ao final do processo. Nikolau, Tsalis e Evangelinos (2019) explicam que as práticas sustentáveis das empresas devem estar direcionadas ao investimento econômico de forma eficaz, ao mesmo tempo em que se determinem metas ambientais e sociais que garantam a proteção do meio ambiente natural e a justiça.

Uma empresa entrevistada citou a preocupação com a modelagem da peça ainda no setor de criação, muito embora fosse destinada mais ao fator econômico (tempo e quantidade de matéria-prima) que sustentável, mas que contribui para a redução de resíduos no setor de corte, indo ao encontro do que preconiza o método de modelagem consciente: uma forma de adaptar o molde para que o resultado tenha o menor índice de desperdício possível (BINELLI, 2020). Quanto mais formas, curvas

e irregularidades tiver a modelagem da peça, mais resíduo ela irá gerar (WONG *et al*., 2013). Alencar *et al.* (2015) informam que, devido à forma dos moldes que não proporcionam um encaixe perfeito, o desperdício pode chegar em até 30% do tecido. Já é comprovado que a modelagem consciente resulta em um aproveitamento superior do tecido (BINELLI, 2020), mas é necessário que o *designer*/estilista tenha um bom conhecimento de modelagem e muita criatividade para que o produto continue sendo atrativo para seu cliente. O que se observa na prática é que nem todos os *designers* têm essa visão da modelagem no processo criativo, pois essa prática não é construída na maioria dos cursos de *design* de moda, fato que pode ser observado pelas grades curriculares.

A seleção da matéria-prima e de aviamentos é primordial para a sustentabilidade dos processos e para a reciclagem, devendo ser sempre a primeira escolha para os gestores e os profissionais responsáveis pelo setor de criação, o que, consequentemente, vai interferir no volume final de resíduos produzidos. É importante que se leve em consideração que a matéria-prima biodegradável, com biopolímeros, orgânica, certificada, reciclada, regenerada, compostável, eco materiais e/ou que possua rastreabilidade, sempre serão a de primeira escolha. Em nenhuma das empresas visitadas em Teresina encontrou-se a opção pela matéria-prima biodegradável, pois os gestores consideram seu custo entre 20% e 30% mais elevado que o custo da matéria-prima comum, que ocasionaria um aumento no custo final de seu produto, inviabilizando sua comercialização em virtude da concorrência. Bastian e Rocco (2009) apontam que, quando, por algum motivo, não se possa fazer uso desse tipo de matéria-prima, a adoção daquelas cujos fornecedores ofereçam informações sobre os tipos de substâncias aplicadas a seus produtos é sempre a escolha seguinte. No entanto, não se observou esse tipo de preocupação com a ética de seus fornecedores nas empresas visitadas.

Ressalta-se que a forma de construção do tecido merece ser considerada, pois pode limitar o posicionamento dos moldes em virtude da trama do tecido, levando a uma geração maior de aparas e de desperdício e, ademais, a largura do tecido interfere diretamente no volume de resíduos produzidos no setor de corte, e determinados tipos de estampas também se apresentam como fatores limitantes para o posicionamento dos moldes. Observou-se que a maioria das empresas visitadas não faz um planejamento prévio e não leva em consideração a estrutura de construção dos tecidos. Porém, algumas evitam o uso dos tecidos com determinadas estampas que possam vir a limitar o posicionamento dos moldes, principalmente tecidos com brilho, barrados e com listras verticais, mas o fato ocorre essencialmente por fatores econômicos. Outras, porém, não usam com frequência, mas não evitam seu uso caso a estampa esteja dentro das tendências ou do tema da coleção.

Quanto à escolha de acessórios e aviamentos, deve-se ter em mente sua composição e estar ciente de que estes dificultam ou inviabilizam a reciclagem de peças após seu descarte. Sugere-se que o *designer*, antes de iniciar qualquer coleção, verifique no estoque o material disponível de forma a incluir seu uso nas novas peças e, além disso, recomenda-se que se realize um planejamento de forma a evitar a compra desnecessária, o que geraria desperdício, além de prejuízo econômico e ambiental.

Verificou-se que, durante a pandemia ocasionada pelo Sars Cov-19, a gestão das empresas passou a considerar a utilização da matéria-prima e aviamentos disponíveis no estoque em virtude da dificuldade de se encontrar materiais disponíveis no mercado e dos altos preços praticados, despertando para a necessidade do controle de seu almoxarifado para que as sobras sejam evitadas e/ou reutilizadas. Começaram a aplicar técnicas de tingimento de aviamentos para alcançar a cor da tendência para que pudessem ser utilizados nas novas coleções. Mas, novamente, percebe-se o predomínio do fator econômico em detrimento do sustentável, mas que contribui com a sustentabilidade do processo. Em mais de 50% das empresas os estoques zeraram, assim como as peças prontas estocadas, o que levou a gestão a repensar a forma de comprar e de utilizar a matéria-prima.

No que tange à composição dos aviamentos, a pesquisa não encontrou relato que demonstrasse o conhecimento e/ou interesse em sua composição nem no uso de aviamentos de diferentes composições em uma mesma peça que pudessem, de alguma forma, dificultar a reciclagem do produto pós-uso.

Considerando-se a importância do setor de enfesto, operação em que o tecido é disposto em camadas sobre a mesa de corte e, sobre este, os moldes, identificou-se o enfesto manual e o enfesto mecânico durante as visitas. Nas indústrias visitadas em Teresina, percebe-se o uso do enfesto manual, com suporte e com carro manual com alinhador de ourela, sendo o mais comum o enfesto com carro alinhador de ourela, apontado neste trabalho como o mais adequado para o porte das empresas visitadas.

Como é comum que as indústrias confeccionem o mesmo modelo no mesmo tecido, variando apenas a cor, encontramos no setor de enfesto muitas variações na largura do mesmo tecido de um mesmo fabricante. Percebe-se que determinados fabricantes não possuem esse controle de qualidade. Para um mesmo produto, diferentes cores apresentam diferentes larguras, o que compromete o rendimento da produção e gera uma quantidade de resíduos que poderia ser minimizada. No setor de encaixe e risco, as empresas visitadas já utilizam em sua totalidade o encaixe informatizado. Esse método aumenta a precisão, maximiza o aproveitamento do tecido, reduz o tempo de realização do risco, minimiza o desperdício, realiza o cálculo da eficiência do uso do tecido simultaneamente e ainda aumenta o lucro (PURANIK; JAIN, 2017).

A literatura aponta o setor de corte como responsável pela produção do maior volume de resíduos nas empresas. Ressalta-se, porém, que o fato ocorre em virtude das decisões tomadas pelo setor de criação. A redução da produção de resíduos deve ser pensada ainda naquele setor com estratégias diferenciadas no desenvolvimento das coleções. Quando não for possível, o foco pode ser direcionado para a reutilização e reciclagem desses resíduos. Destaca-se também o desperdício que chega ao setor de corte tanto em termos de ética ambiental como de perspectivas econômicas. Desse modo, deve-se ir ao encontro das estratégias de gerenciamento de resíduos de forma a evitar desperdícios. Entretanto, o que se observa é que nas empresas visitadas não há nenhum planejamento do setor de criação voltado para a redução do volume de resíduos que se concentra no setor de corte, corroborando Enez e Kipoz (2020) que apontaram que 36,7% das empresas não realizam esforços para eliminar o desperdício no setor de corte e costura.

Os resíduos têxteis encontrados na pesquisa foram as aparas no setor de corte, restos de tecidos que ficam nos rolos, peças com defeitos, peças que não tiveram boa aceitação e que, mesmo assim, permanecem no estoque. Parte das aparas é destinada a doação para entidades beneficentes ou para indivíduos comuns a fim de promover a confecção de tapetes e fuxico e, outra parte, as menores, é descartada para a coleta municipal comum, tendo como destinação final o aterro sanitário.

Não se identificou a reciclagem desses resíduos no momento da pesquisa por parte das empresas entrevistadas, mas algumas informaram que houve um tempo em que uma grande indústria de colchões da cidade recebia e/ou recolhia esses resíduos, os quais passavam por diferentes processos e eram utilizados como enchimento para os colchões, mas que, no momento da realização da pesquisa, não estavam mais realizando essa coleta. Para Leal Filho *et al.* (2019) e Islam e Bhat (2019), o setor do vestuário é um grande gerador de resíduos e produtor de perdas de matéria-prima devido ao excesso de produção e, eles, por sua vez, sugerem que a reciclagem e o reúso são necessários visto que trazem inúmeras vantagens ao meio ambiente.

Destaca-se que a pesquisa não identificou o montante de resíduos produzido por coleção nem o montante destinado ao aterro, pois o tempo de visita não possibilitou essa observação, visto que vários dias são necessários para a produção de uma coleção e a visita limitou-se a um turno em decorrência do curto período disponível pelo gestor para acompanhar os pesquisadores e em virtude do aumento de casos de Covid-19 no período de realização da pesquisa. Os retalhos que se caracterizam como retalhos de fim de rolo são, em sua maioria, vendidos aos próprios funcionários. As peças com defeitos e aquelas que não tiveram boa aceitação são vendidas em feiras promocionais de fim de ano com preço de custo. Reconhece-se a dificuldade em destinar corretamente os resíduos têxteis, principalmente as aparas, visto que a cidade não possui coleta específica para esse tipo de resíduo nem cooperativas que possam reciclá-los ou reutilizá-los.

No setor de montagem, grande parte das empresas visitadas faz uso da terceirização, em busca de preços cada vez mais reduzidos e competitivos, subcontratando entre 50% e 70% da montagem de suas peças. A terceirização ocorre com costureiras, em sua maioria ex-funcionárias de alguma empresa, que trabalham em casa, onde se dividem entre o trabalho de costura e os afazeres domésticos indo ao encontro das informações fornecidas pela Agenda Moda Brasil (2019), que afirma haver incidência de terceirização no setor, cujo risco de graves violações aos direitos humanos e trabalhistas é alto. Leite, Silva e Guimarães (2017) complementam informando que a montagem das peças quase não é mais realizada na Europa e América do Norte, está ficando restrita aos países latino-americanos e ao Sul da Ásia, onde é executada em oficinas ou nos próprios domicílios.

4 CONSIDERAÇÕES FINAIS

As Microempresas Individuais (MEI) e as Microempresas (ME) de confecção do vestuário visitadas em Teresina reconhecem a produção de resíduos como um dano ambiental, mas não promovem nenhum tipo de intervenção no processo produtivo que possa, de alguma forma, reduzir o montante de resíduos produzido.

Identificaram-se alguns tipos de resíduos e, entre eles, o destaque em volume se dá para as aparas. Destas, parte é doada para a confecção de tapetes e fuxicos por indivíduos e para instituições de caridade, e outra parte é descartada para a coleta comum. Uma das limitações da pesquisa foi a impossibilidade de se quantificar o volume produzido mensalmente e o volume que é doado ou descartado. Também se destacam as limitações e dificuldades encontradas impostas pela pandemia da Covid-19, que limitou o número de visitas para a pesquisa.

Diante dos resultados, pode-se deduzir que os gestores das empresas visitadas não se comprometem com as práticas de proteção ambiental. A maioria reconhece a sustentabilidade apenas no controle dos resíduos do setor de corte. Reconhecem a necessidade de um profissional especializado no assunto, mas não possuem reservas financeiras para essa finalidade. Para os gestores, a sustentabilidade é um nicho de mercado que não atrai seu público-alvo, portanto, não está dentro da sua missão.

As MEI e as ME representam a realidade não só de Teresina, mas também a realidade brasileira, apontando para a necessidade de novos estudos que indiquem formas eficazes de se implementar práticas de sustentabilidade ambiental e social com baixos custos para a realidade dessas empresas.

NOTAS

1 | O trabalho fará parte dos anais do X Enanppas.

2 | Refere-se a agasalhos, bermudas, *blazers*, blusas, blusões, camisas esporte e social, calças compridas, *shorts*, camisetas, capas, casacos, fantasias, jaquetas, paletós, ternos, saias, vestidos, conjuntos, sobretudo, roupas para a prática de esportes e moda praia (CNAE, 2010). Disponível em: https://concla.ibge.gov.br/busca-online-cnae.html?subclasse=1412601&tipo=cnae&view=subclasse. Acesso em: nov. 2021.

3 | A legislação brasileira (Lei 6.183, de 11 de dezembro de 1974) dá ao IBGE a responsabilidade de coordenar o sistema estatístico nacional.

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Integrated and sustainable agroecological production for medicinal plants: a proposal based on strategic management

Produção agroecológica integrada e sustentável para plantas medicinais: uma proposta a partir da gestão estratégica

Jeferson Adriano e Silva Assunção [1]

Ygor Jessé Ramos dos Santos [2]

João Carlos da Silva [3]

Nina Cláudia Barboza da Silva [4]

Danilo Ribeiro de Oliveira [5]

[1] Master in Pharmaceutical Science and Technology, Professor, Centro de Responsabilidade Socioambiental do Jardim Botânico do Rio de Janeiro, CRS/JBRJ, Rio de Janeiro, Brazil
E-mail: jefersonadriano.sa@gmail.com

[2] Master in Plant Biology, Laboratory technical advisor and Professor, Centro de Responsabilidade Socioambiental do Jardim Botânico do Rio de Janeiro, CRS/JBRJ, Rio de Janeiro, Brazil
E-mail: ygorjesse@jbrj.gov.br

[3] Master in Evaluation, Coordinador, Centro de Responsabilidade Socioambiental do Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, CRS/JBRJ, Rio de Janeiro, Brazil
E-mail: jcsilva@jbrj.gov.br

[4] Doctor in Plant Biotechnology, Associate Professor II, Universidade Federal do Rio de Janeiro, UFRJ, Rio de Janeiro, Brazil
E-mail: ninacbs@gmail.com

[5] Doctor in Natural Products Chemistry, Associate Professor, Universidade Federal do Rio de Janeiro, UFRJ, Rio de Janeiro, Brazil
E-mail: danilopharma@gmail.com

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ABSTRACT

A management plan based on Integrated and Sustainable Agroecological Production (Pais) technology for the cultivation of medicinal plants, through a case study. The Swot-AHP technique was adopted to

evaluate problems to agroecological cultivation, indicating stages of the implementation work, before the physical structuring of the project, integrated with a participative social action with employees of the institution who revealed the use of 64 medicinal plants, highlighting boldo, lemongrass, and lemon balm, while 174 plant species were identified in official Brazilian documents. The lack of electricity and funding delays by funders are the most significant problems, while the space for work and gardening courses are the best potential. The integration of these data has proposed the implementation of teams for fundraising and project implementation, based on a list of medicinal species to compose the future structure made with Pais social technology.

Keywords: Strategic management. Swot-AHP. Agroecology. Cultivation. Medicinal plants.

RESUMO

Foi proposto um plano de gestão baseado na tecnologia de Produção Agroecológica Integrada e Sustentável (Pais) para cultivo de plantas medicinais, por meio de um estudo de caso. Adotou-se a técnica Swot-AHP para avaliar problemas no cultivo agroecológico, indicando etapas do trabalho de implantação, antes da estruturação física do projeto, integrado a uma ação social participativa com funcionários da instituição que revelaram uso de 64 plantas medicinais, destacando-se boldo, capim-limão e erva-cidreira, enquanto 174 espécies vegetais foram levantadas em documentos oficiais brasileiros. A falta de eletricidade e o atraso da verba pelos financiadores são os maiores problemas, enquanto o espaço para trabalho e curso de jardinagem são as melhores potencialidades. Por meio da integração desses dados, foi proposta a implantação de equipes para captação de recursos e para implantação de projetos, tendo por base uma lista de espécies medicinais para compor a futura estrutura feita com tecnologia social Pais.

Palavras-chave: Gestão estratégica. Swot-AHP. Agroecologia. Cultivo. Plantas medicinais.

1 INTRODUCTION

Organic farming is used in agroecology, which is understood as the union of traditional knowledge with different sciences, to develop ecologically sustainable, economically viable, and socially just agricultural models (ALTIERI, 2004).

Based on the advances made with agroecological models for cultivation and plant production with respect for the environment, in 1999, the Agricultural Engineer Aly Ndiaye conceived with a family of rural farmers in Petrópolis-RJ a cultivation system called Integrated and Sustainable Agroecological Production (Pais). This aimed to exercise social inclusion, food security, fight hunger, extreme poverty, and implement new healthy eating habits for low-income communities by integrating plants and animals without pesticides, following the agroecological concept (NDIAYE, 2016).

Pais social technology proposed a circular-shaped mandala, integrating plant species (vegetables, aromatics, and spices) with a central chicken coop and/or fish tank so that it is possible to use bird or fish faeces for fertilisation and the remains of vegetables for animal feed. From the availability of all the materials and inputs necessary for the assembly of this agroecological cultivation technology, in addition to technical consultancy for 30 months, several systems were implemented in the national territory, mainly in small rural properties, to add security and sovereignty food, as well as income generation (NDIAYE, 2016; SEBRAE, 2008).

However, there are still few results on the systematisation of data to construct this social technology (SILVA et al., 2018).

Swot analysis (Strengths, Weaknesses, Opportunities, and Threats) is a preventive technique applied mainly in early research and projects to minimise future problems. It can help in the data systematisation

process since it lists both internal factors, Strengths, and Weaknesses, as well as external factors, Opportunities, and Threats, which facilitates the analysis of conditions that can influence negatively and positively before starting the structuring process of a given project, promoting security in future actions (SOUSA et al., 2019).

With a qualitative character, Swot is an excipient for many applications, such as General Business Administration, Marketing and Marketing, Healthcare, Cosmetics, Learning and Education, Agriculture, Forestry, Environment, Medicine and Pharmacy, Textile Industry, Tourism, Manufacturing, Transport, Library, Construction, Oil and Gas, Armed Forces, Financial Market among others (GHAZINOORY; ABDI; AZADEGAN-MEHR, 2011). Kurttila et al. (2000), observing this bottleneck, proposed the union of Swot analysis with a quantitative technique called Analytic Hierarchy Process (AHP).

To carry out this hybrid method (Swot-AHP), steps were established such as carrying out the Swot analysis, paired comparisons between Swot factors carried out in all groups within the Swot analysis, paired comparisons between the four groups within the Swot matrix (strengths, weaknesses, opportunities, and threats) and the use of results in the strategy formulation and evaluation process (GHAZINOORY; ABDI; AZADEGAN-MEHR, 2011).

Given this panorama, this work aimed to apply a tool to build a strategic management plan with Swot-AHP analysis to select and cultivate plants with medicinal properties, based on Integrated and Sustainable Agroecological Production (Pais) technology through a case study.

2 METHODOLOGICAL PROCEDURES

2.1 STUDY PLACE

The Almirante Milcíades Portela Alves Instruction Center (Ciampa) occupies an area of 4,500,000 m². It is located in the Guandu do Sapê Naval Complex, on the banks of Avenida Brasil in Campo Grande, Rio de Janeiro-RJ, housing the project Management Company Navais (Emgepron), linked to the Ministry of Defense (MOTA, 2008). Emgepron is responsible for producing ammunition and the Socio-environmental and Ecological Adequacy Program of the Guandu do Sapê Naval Complex (EMGEPRON, 2017).

2.2 PROPOSAL OF THE MANAGEMENT PROCESS

After a structural analysis of the socio-environmental sector of Ciampa, a Swot/Fofa analysis was developed, listing the positive and negative points, where it was possible to identify the internal factors (Strengths and Weaknesses) and external factors (Opportunity and Threats) to generate matrices quali-quantitative (SOUSA et al., 2019).

The initial interview with the coordinator of environmental projects at Ciampa listed all the internal and external factors of the socio-environmental sector facing the implementation of social technology Pais (ABE; MIRAGLIA, 2020). A chart with the information was created from this checklist using the Lucidchart flowchart and diagram creation software.

From the qualitative information (Swot analysis), quantitative analyses were performed (Analytic Hierarchy Process) to classify the relationships. This rating categorises information on a scale of 0 to 3: No relation at all (0); Weak relationship (1); Moderate relationship (2) and Strong relationship (3) (KURTTILA et al., 2000).

Two 9x9 matrices were generated in the classification of relations. The first matrix numbers the information relation and sums each column and row. The second matrix exposes all the strong ties, with divisions into priority thematic axes to resolve the problems.

This work built an investigative case study with qualitative and quantitative methodological characteristics (GL, 2008) through non-participant observation and semi-structured interviews and the maximum use of the answers, considerations, and comments obtained (FORMIGA JÚNIOR; CÂNDIDO; AMARAL, 2015).

2.3 STRATEGIC SELECTION OF MEDICINAL SPECIES

The species medicinal were selected from current normative documents that guide the research and/or use of medicinal and herbal plants within the federal government: Brazilian Pharmacopoeia – 6th ed. (2019) (FB), Form of Herbal Medicines of the Brazilian Pharmacopoeia (2018) (FFFB), Herbal Medicine Memento of the Brazilian Pharmacopoeia (2016) (MFFB), National List of Essential Medicines (2018) (Rename) and National List of Medicinal Plants of Interest to SUS (2009) (Renisus).

2.3.1 INTERVIEWS AND SALIENCE INDEX (IS)

There were 2 meetings with Ciampa officials who know medicinal plants to explain social participation in choosing medicinal species to compose the structure to be made with the Pais social technology.

In this context, semi-structured interviews were carried out with the aid of a questionnaire divided into socioeconomic questions and questions related to medicinal plants (popular name, indications of widespread use, and place of acquisition).

The list of medicinal plants mentioned in the interviews (free list) was processed to calculate the Salience Index (IS) using the Anthropac 4,983 tool (Analytic Technologies, USA) (ALBUQUERQUE *et al*., 2014).

The medicinal plants calculated using the IS were crossed with the list made using the principal regulations published by the Ministry of Health.

Due to the impossibility of collecting to identify the medicinal plants mentioned by the informants, the technique called “taxonomic clues” was used to find the scientific names of the said plant species. This technique equates the famous names of the medicinal plants mentioned with the plant species scientifically named in the literature (BOCHNER *et al*., 2012). The scientific nomenclature was updated through the Flora do Brasil list (2020), Tropicos (2020), and The Plant List (2013).

The Ethics Committee approved this research, Opinion CEP/HUCFF/FM/UFRJ nº 3.234.966. All informants signed an Informed Consent Term, giving prior knowledge and authorization to collect and use the data collected.

The data obtained were organised into tables, analysed, and presented as graphs prepared with the help of the Excel® program.

3 RESULTS AND DISCUSSION

3.1 PROPOSAL OF THE MANAGEMENT PROCESS

3.1.1 QUALITATIVE ANALYSIS

From the analysis of the interviews with the coordinator of the socio-environmental sector, it was possible to build the picture with the Swot analysis. Eighteen internal and external factors were surveyed related to the future implementation of Pais social technology.

These factors listed in the Swot analysis (Figure 1) helped to build future scenarios and action strategies capable of nullifying or mitigating possible interferences in the execution of sustainable cultivation in the moulds of Pais social technology. Therefore, visualising all positive influencing factors and negative listed consolidates the understanding of the most beneficial ideas to strengthen cultivation attributes (OLIVAL, 2016).

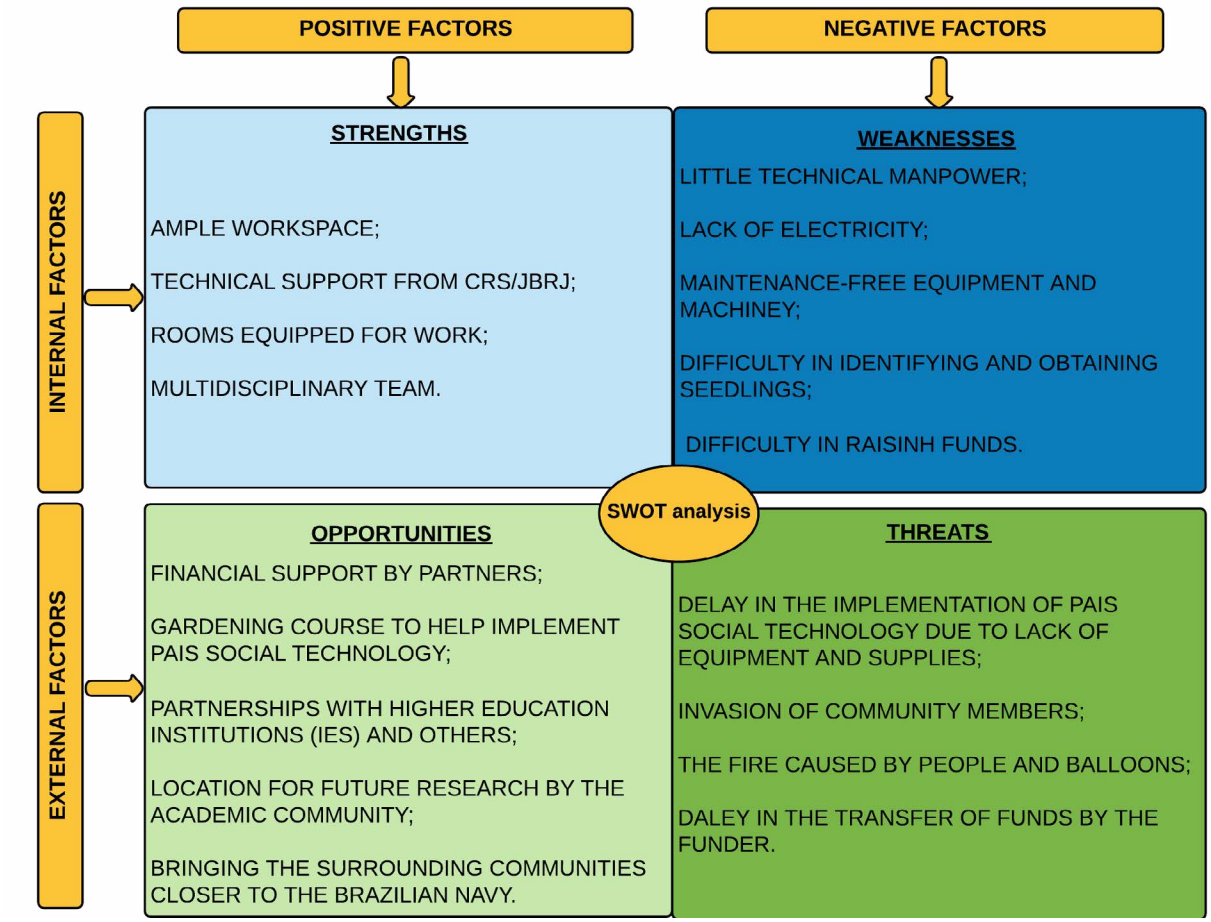

Figure 1 | Swot analysis elaborated on the main negative and positive factors related to implementing social technology Pais in the Naval Complex of the Brazilian Navy in Campo Grande/RJ.

Source: Own elaboration based on Kurttila et al. (2000).

- Weaknesses and Threats

Through the analysis of the actions, significant challenges were found, described as weaknesses, they are, “Low technical manpower”, “Lack of electricity”, “Maintenance equipment and machinery”, “Difficulty in identifying and obtaining seedlings” and “Difficulty in raising funds”.

These weaknesses are related to the lack of funds transfer, especially for the first three mentioned above. According to the manager of the socio-environmental sector of Ciampa, the budget for the socio-environmental program is less than its forecast. As a result, weaknesses may be delayed in resolution or not resolved as a matter of priority.

Threats can happen or not; this will depend on the relationship between threats x opportunities, threats x strengths, and threats x weaknesses, calculated in the classification of relationships.

The delay in the transfer of funds by the financier and the delay in implementing Pais social technology due to lack of equipment are closely linked. For the physical execution of the cultivation, it is necessary to acquire tools, plant species, and materials for planting. Thus, seeking financial resources from other places or forming partnerships with other institutions are relevant alternatives to prevent these threats.

The invasion of people from the local community does not generate danger for the cultivation since the area belongs to the Brazilian Navy's military corps. This invasion occurs because of animals such as horses and oxen that flee into Ciampa. Therefore, their owners enter to rescue them.

In the case of fires caused by people and balloons, there is a solution already used. The area is divided by small roads without vegetation that serves to control a possible fire.

Given this Swot analysis, it is known that alternative production models have critical challenges (threats and weaknesses) to be overcome to implement and sustain agroecological projects successfully. Therefore, there must be dialogue and collective learning (SANTO; GOMES; PIRES, 2019). Therefore, this analysis must be permanent, bring the team together to discuss the available solutions as a group and evaluate and make decisions seeking to reconcile the actions necessary for developing and elaborating goals (KLOCK; MARINI; GODOY, 2019).

- Strengths and Opportunities

The forces show that the structural part is prepared to receive a large-scale project. There is ample space for work with crowded rooms and counting on the multidisciplinary team of CRS/JBRJ through a technical cooperation agreement.

The strengths and opportunities can increase the success of the project, mitigating a large part of the weaknesses, because there is the possibility of diversifying funding sources, that is, seeking support from industries and institutions that deal with environmental projects in the surroundings of Ciampa, in addition to Furthermore, the gardening course aimed at the local community and partnerships with Higher Education Institutions (IES), will be part of the insertion of labour and the input of financial resources to assist in the implementation of Pais social technology.

The strengths and opportunities brought the visualisation of the possibilities capable of facing the weaknesses and threats that could harm the construction of the Pais social technology.

Swot analysis is a powerful tool only for the qualitative part of this project and other authors who carried out strategic management studies with medicinal plants (SILVA et al., 2017; SINGH et al., 2019).

According to the literature, it could be observed that most scientific studies build Swot matrices relating strengths, opportunities, weaknesses, and threats, without quantitatively evaluating the relationship of positive and negative factors present (MIRANDA et al., 2018; SILVA et al., 2017).

3.1.2 QUANTITATIVE ANALYSIS

The negative and positive factors were grouped using the Swot/Fofa matrix, which generated an overview of all actions that help and hinder the structuring of Pais social technology, while the quantitative analysis grouped the main negative and positive factors to rank the decision making regarding the problems of most significant to most minor importance (Weaknesses and Threats) and the greatest and smallest positive points (Strengths and Opportunities).

From the first matrix that shows the sum of each column and row of the classification of the relationships, it was possible to identify two specific negative factors: lack of electricity – 22 points and delay in the transfer of funds by funders – 23 points (Table 1). These actions may initially impede the structuring of the Pais social technology.

On the other hand, it was possible to verify two positive actions that scored the most: ample space for work – 21 points and a gardening course to help implement the Pais social technology – 23 points. With the gardening course, it is possible to minimise the impacts generated by the delay in funds. There will be a workforce to carry out the actions of structuring the Pais social technology. Activities occur naturally. Thus, the solution to the lack of electricity is the consolidation of a fundraising team, verified in Table 2.

Table 1 | Quantitative matrix of the Swot-AHP analysis with the sum of the most relevant positive and negative factors for implementing social technology Pais at the Ciampa.

		STRENGTHS				WEAKNESSES					
		Ample workspace	Rooms equipped for work	Multidisciplinary team	Technical support from CRS/JBRJ	Little technical workforce	Lack of electricity	Maintenance-free equipment and machinery	Difficulty in identifying and obtaining seedlings	Difficulty in raising funds	TOTAL OF POINTS
OPPORTUNITIES	Financial support by partners	1	1	2	1	3	3	3	2	3	19
	Gardening course to help implement PAIS social technology	3	2	2	2	3	3	3	2	3	23
	Partnerships with higher education institutions (IES) and others	3	2	2	1	2	2	1	2	3	18
	Location for future research by the academic community	3	2	2	1	2	3	1	2	3	19
	Bringing the surrounding communities closer to the Brazilian Navy	3	2	2	1	2	3	0	0	0	13
THREATS	Delay in the implementation of PAIS social technology due to lack of equipment and supplies	2	2	2	1	2	3	3	0	3	18
	Delay in the transfer of funds by the funder	3	2	2	3	3	3	3	1	3	23
	Invasion of community members	0	1	0	0	0	0	0	0	0	1
	The fire caused by people and balloons	3	3	1	0	2	2	3	0	2	15
	TOTAL OF POINTS	21	17	15	10	19	22	17	9	20	

Source: Own elaboration based on Kurttila et al. (2000) and Chang and Huang (2006).

Based on the delay or lack of transfer of financial resources, the lack of electricity is more prominent, impacting the activities to be carried out. Given this context, Rosa (2016) explains that electricity is part of the daily lives of individuals, both in public environments and at work; this change in the social consumption patterns of populations, reflected in the conformation of the living standards of the society that today depends on electricity usage. The author emphasises that the problem of access to electricity is caused by the lack of access to this service and not by the interruption of access due to the ineffectiveness of public policies to make access to electricity mandatory.

The analyses by Miranda et al. (2018) corroborate the weakness and threat of greater relevance presented here. Therefore, public management depends on financial resources to solve structural problems. It is essential to transfer funds for improvement and quality of services to be performed. Miranda et al. (2018) also highlight the importance of forming partnerships with the surrounding community in activities carried out in the public space, which somehow helps develop activities not carried out due to lack of transfer of financial resources.

The voluntary support of members of educational institutions and partner companies, together with the consolidation of the gardening course, a vitalortant role in meeting the need for personnel to prepare the Pais structure and contribute to individuals' professional and personal development. Consequently, the public department acquires several tasks that the State cannot supply; these ties between society and public bodies are strengthened (BARELI; SOUSA, 2015).

The gardening course and volunteer support will be attended by members of the surrounding communities and the general public. Some of the Ciampa employees and interns interviewed and who live nearby expressed interest in improving their knowledge in plant cultivation. Gardening courses have already taken place in the socio-environmental sector of Ciampa, and there is interest in the return of these activities; the coordinator even meets the president of the closest community association called Parque São Francisco, enabling contact to publicise the proposed activities.

In Table 2, the strong relationships (3) were able to show the need to introduce a project implementation team and a fundraising team into the socio-environmental sector of Ciampa; these teams will guide and support the progress and support of the project.

Table 2 | Quantitative matrix of the Swot-AHP analysis with emphasis on solid relationships (3). It is possible to highlight the teams necessary for the implementation of Pais social technology at the Ciampa.

Fundraising team

Project implementation team

		STRENGTHS				WEAKNESSES				
		Ample workspace	Rooms equipped for work	Multidisciplinary team	Technical support from CRS/JBRJ	Little technical workforce	Lack of electricity	Maintenance-free equipment and machinery	Difficulty in identifying and obtaining seedlings	Difficulty in raising funds
OPPORTUNITIES	Financial support by partners					3	3	3		3
	Gardening course to help implement PAIS social technology	3				3	3	3		3
	Partnerships with higher education institutions (IES) and others	3								3
	Location for future research by the academic community	3					3			3
	Bringing the surrounding communities closer to the Brazilian Navy	3					3			
THREATS	Delay in the implementation of PAIS social technology due to lack of equipment and supplies						3			3
	Delay in the transfer of funds by the funder	3			3	3	3	3		3
	Invasion of community members									
	The fire caused by people and balloons	3	3					3		

Source: Own elaboration based on Kurttila et al. (2000).

Santos, Negrão, and Saboya (2018) clarify that changes in public management and/or lack of financial resources generate cancellation or delay in transferring money to institutions that need it to survive. However, the authors emphasise the importance of good strategic management focused on raising and managing financial resources, on managing money in a balanced way within the institution.

The socio-environmental sector of Ciampa has the coordinator to carry out the management part, which ranges from the amount of the human resource to the financial position; that is, it assumes different roles as a manager and overloads the daily tasks. Hiring qualified personnel to help, especially fundraising and implementation, is necessary for the project to take the first structuring steps.

The implementation axis can be carried out in three ways: the first option is through the technical cooperation agreement with the CRS/JBRJ, bringing its professionals and interns to help structure the project, together with volunteers from the surrounding community, to supply the needs of the lack of personnel to carry out manual work. On the other hand, the second option depends on fundraising; that is, it will be necessary to increase the number of qualified personnel in the socio-environmental sector of Ciampa, as the lack of professionals in this sector is one of the main problems reported by the coordinator.

The third option has as alternative social participation focused on developing activities in the socio-environmental sector of Ciampa. This alternative corroborates the conclusions of Petrus, Kátia, and Pereira Júnior (2016), who clarify that social participation, correctly implemented, generates local economic, social, and political growth.

Another alternative that will sustainably help the development of activities is to carry out the structuring of the Pais social technology with materials found at Ciampa. The plastic boxes that carry the ammunition are discarded and can be reused to prepare flowerbeds and the stakes from the Sansão-do-campo trees (Mimosa caesalpiniifolia Benth.), which are located in a large area within Ciampa.

The construction of this Pais social technology will generate didactic interaction with the target audience (education and research institutions and interested people), medicinal plant-based inputs for the use of employees, and programs that work with phytotherapy, production of certified seedlings for donation, as well as carrying out organic cultivation with several plant species in a place that suffered deforestation.

3.2 SOCIAL PARTICIPATION IN THE SELECTION OF MEDICINAL SPECIES

The first meeting held on May 22, 2019, was attended by 14 employees appointed by the coordinator and the most experienced gardener in the socio-environmental sector of Ciampa. In the days following the first meeting, 11 employees agreed to a semi-structured interview.

According to the interviews carried out, it could be seen that the two sectors (socio-environmental and factory) account for the most significant percentage from the perspective of the place where the informants see the medicinal species they know and use (Figure 2), showing the relevance mainly of the Social and environmental sector in the construction of knowledge about medicinal plants.

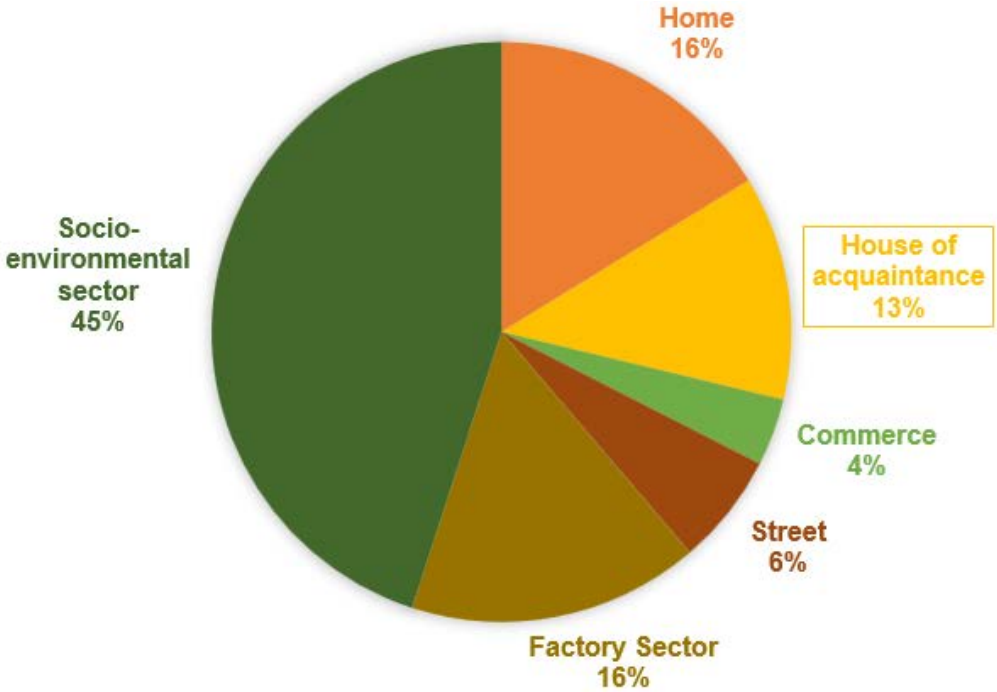

Figure 2 | Location of plants mentioned in interviews with informants from Ciampa.

Source: Authors

The study by Faria and Albuquerque (2018) on socioeconomic factors that can affect knowledge of medicinal plants clarifies that frequent contact with medicinal plants positively influences the knowledge of the population participating in the research. This conclusion corroborates this work, given that the work environment of the Ciampa informants has the two places with the highest percentages of citations, that is, most of the plants they know are planted in the workplace.

One of the factors contributing to the informants' knowledge is that Ciampa has an extensive green area, as it is part of the Marapicu-Gericinó-Mendanha (MGM) mountain range essentially has native Atlantic Forest vegetation. A good part of this location is an APA (Environmental Protection Area) (MOTA, 2008).

This extensive green area surrounds two sectors: socio-environmental and factory. In the socio-environmental sector, reforestation and studies of degraded areas occur within Ciampa. In this way, Ciampa contributes to knowledge about medicinal plants and other non-medicinal plants, considering that most informants reported having little space for planting in their homes.

64 medicinal plants were mentioned, totalling 119 citations. Considering the analyses carried out with all plants, boldo stood out for having been cited by 8 informants (8 citations = 72.7%), followed by lemongrass and lemon balm with 6 (54.5%) citations each (Figure 3).

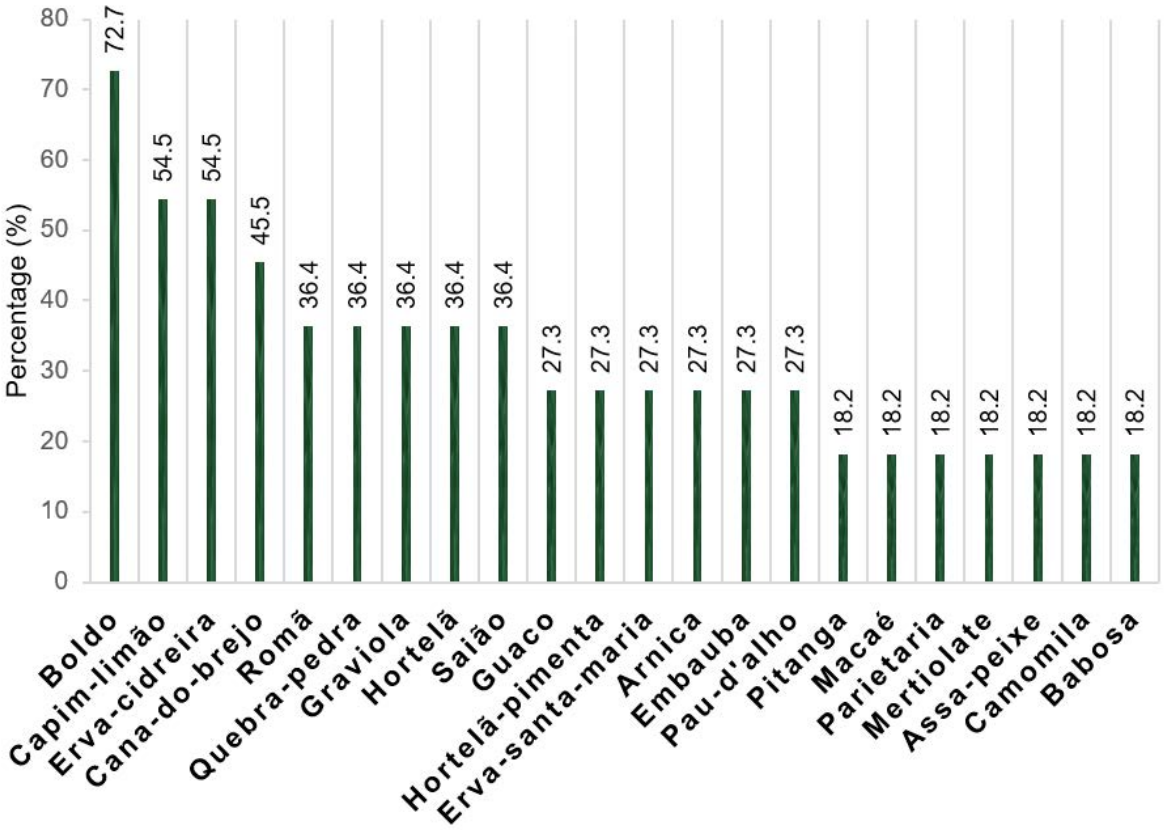

Figure 3 | Frequency of citations of plants was obtained through interviews carried out with informants from the Ciampa. Simplified graph with a minimum of 2 quotes.

Source: Authors.

The species popularly named boldo are among the most cited in ethnobotanical studies in Brazil (GOIS *et al*., 2016). Borges and Moreira (2016) surveyed medicinal species used by family members of students attending courses at the Federal Institute of Mato Grosso Campus Confresa, where boldo (*Plectranthus barbatus* Andr.) obtained 10.6%, lemongrass (*Cymbopogon citratus* (DC.) Stapf) 9.5% and *Aloe vera* (L.) Burn f) 7.7% of citations.

Through the order of citation of each informant, the Salience Index (IS) was calculated for the plants of greatest cultural importance, namely: boldo (IS = 0.649), followed by lemongrass (IS = 0.435) and lemon balm (IS = 0.360). With this, it is possible to demonstrate the importance of local knowledge of the species popularly known as boldo, lemongrass, and lemon balm (Table 3), which are precisely the same species that had the highest number of citations.

Table 3 | List of species classified by the Salience Index (IS), obtained from citations from the Ciampa informants.

SPECIES	*IS*	*SPECIES*	*IS*
Boldo	0,649	Marissol	0,061
Capim-limão	0,435	Carqueja	0,061
Erva-cidreira	0,360	Sabugueiro	0,059
Saião	0,214	Erva-doce	0,059
Cana-do-brejo	0,196	Canela	0,057
Arnica	0,193	Aveloz	0,053
Quebra-pedra	0,177	Poejo	0,053
Guaco	0,177	Coloral	0,051
Embaúba	0,171	Hamamelis virginiana	0,051
Babosa	0,152	Beterraba	0,045
Macaé	0,140	Gengibre	0,045
Camomila	0,135	Pitanga	0,043
Graviola	0,130	Arruda	0,040
Hortelã	0,130	Melancia	0,040
Pau-d'alho	0,128	Picão	0,034
Mertiolate	0,127	Rosa-branca	0,032
Erva-de-santa-maria	0,119	Alecrim-do-campo	0,032
Romã	0,108	Agrião	0,030
Hortelã-pimenta	0,099	Limoeiro	0,030
Boldo-do-chile	0,091	Jojoba	0,030
Pinhão-roxo	0,091	Rosa-mosqueta	0,020
Jaborandi	0,091	Dormideira	0,020
Penicilina	0,086	Aroeira	0,017
João-duro	0,086	Arnica-da-horta	0,016
Dente-de-leão	0,081	Abacate	0,015
Cordão-de-frade	0,080	Alho	0,015
Insulina	0,080	Joazeiro	0,013
Mamão-macho	0,071	Maracujá	0,011
Melão-de-são-caetano	0,064	Novalgina	0,010
Assa-peixe	0,062	Goiabeira	0,010
Parietária	0,061	Cravo-da-índia	0,006
Mangueira	0,061	Erva-de-bicho	0,005

Source: Authors.

In a survey of medicinal plants in 4 districts of the municipality of Resende/RJ, it was observed that the boldo was are among the 10 most culturally important species (BALDINI, 2015).

The importance of the species named boldo is remarkable. In ethnobotanical surveys in Brazil (GOIS *et al*., 2016), both urban and peri-urban communities. It made necessary the knowledge of the species with the same popular name and a deep understanding of their medicinal and adverse effects.

3.3 LIST OF SELECTED MEDICINAL SPECIES

The survey carried out through documents made available by the federal government resulted in 174 medicinal species. In comparison, the list of plants surveyed with Ciampa informants after applying the "taxonomic clues" methodology resulted in 85 species. After processing and joining both lists, it was possible to obtain the quantity of 209 species, of which 66 are native (Table 4). This list will be used to elaborate the cultivation, following the norms of the Pais social technology. However, the technical staff of CRS/JBRJ will screen to choose the species that best adapt to the region of Campo Grande/RJ.

Table 4 | List of medicinal species mentioned by informants from the Ciampa correlated to documents made available by the federal government.

Nº	*Scientific Name*	*Common Name*	*Cit*	*Na*	*Ex*	*Nat*	*Cul*	*FB*	*FFFB*	*MFFB*	*RENAME*	*RENISUS*
1	*Absinthium vulgare* Lam. = *Artemisia absinthium* L.	Losna					X					X
2	*Achillea millefolium* L.	Mil-folhas	X			X			X			X
3	*Achyrocline satureioides* (Lam.) DC.	Macela		X				X	X			
4	*Aconitum napellus* L.	Acônito			X			X				
5	*Actaea racemosa* L.	Erva-de-são--cristóvão			X				X	X		
6	*Aesculus hippocastanum* L.	Castanheiro--da-índia					X	X	X	X		
7	*Allium sativum* L.	Alho	X				X	X	X	X		X
8	*Aloe africana* Mill.	Babosa	X				X	X				
9	*Aloe ferox* Mill.	Babosa	X				X	X				
10	*Aloe spicata* L. f	Babosa	X				X	X				
11	*Aloe vera* (L.) Burm. f.	Babosa	X				X	X		X	X	X
12	*Aloysia polystachya* (Griseb.) Moldenke	Burrito			X				X			
13	*Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm	Colônia					X		X			X
14	*Alternanthera brasiliana* (L.) Kuntze	Penicilina	X	X								
15	*Althaea officinalis* L.	Malva-branca			X			X				
16	*Anacardium occidentale* L.	Cajueiro		X								X
17	*Anadenanthera colubrina* (Vell.) Brenan	Angico-branco		X				X				
18	*Ananas comosus* (L.) Merril	Abacaxi		X								X
19	*Anethum graveolens* L.	Endro				X		X				
20	*Annona muricata* L.	Graviola	X				X					

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
21	*Arctium lappa* L.	Bardana				X			X			
22	*Arctostaphylos uva-ursi* (L.) Spreng.	Uva-ursi			X			X				
23	*Arnica montana* L.	Arnica	X		X			X				
24	*Atropa belladonna* L.	Beladona			X			X				
25	*Attalea speciosa Mart. ex Spreng. = Orbignya speciosa* (Mart.) Barb. Rodr.	Babaçu		X								X
26	*Baccharis articulata* (Lam.) Pers.	Carqueja-doce	X	X								
27	*Baccharis dracunculifolia* DC.	Alecrim-do--campo	X	X								
28	*Baccharis trimera* (Less.) DC.	Carqueja	X	X				X	X			X
29	*Bauhinia affinis* Vogel	Pata-de-vaca		X								X
30	*Bauhinia forficata* Link	Pata-de-vaca		X								X
31	*Bauhinia variegata* L.	Pata-de-vaca					X					X
32	*Beta vulgaris* L.	Beterraba	X				X					
33	*Bidens alba* (L.) DC.	Picão-branco	X	X								
34	*Bidens pilosa* L.	Picão-preto				X						X
35	*Bixa orellana* L.	Urucum	X	X								
36	*Bryophyllum pinnatum* (Lam.) Kurz	Folha-da-fortuna	X		X							
37	*Buxus chinensis* Link = *Simmondsia chinensis* (Link) C.K. Schneid.	Jojoba	X		X							
38	*Calendula officinalis* L.	Calêndula					X	X	X	X		X
39	*Carapa guianensis* Aubl.	Andiroba		X								X
40	*Carica papaya* L.	Mamoeiro	X			X						
41	*Casearia sylvestris* Sw.	Guaçatonga		X								X
42	*Cecropia ficifolia* Warb. ex Snethl.	Embaúba	X	X								
43	*Centella asiatica* (L.) Urb.	Centelha-asiá-tica				X		X				
44	*Cinchona calisaya* Wedd.	Quina			X			X				
45	*Cinnamomum cassia* (L.) J. Presl	Canela-da--china	X				X	X				
46	*Cinnamomum verum* J. Presl	Canela	X		X			X				

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
47	*Cissus sicyoides* L. = *Cissus verticillata* (L.) Nicolson & C.E.Jarvis	Insulina-vegetal	X	X								
48	Citrullus lanatus *(Thunb.) Matsum. & Nakai*	Melancia	X				X					
49	*Citrus ×limon* (L.) Osbeck	Limão	X			X		X				
50	*Citrus aurantium* L. subsp. Aurantium	Laranjeira-azeda					X	X				
51	*Citrus sinensis* (L.) Osbeck	Laranjeira-doce					X	X				
52	*Cola nitida* (Vent.) Schott & Endl.	Noz-de-cola			X			X				
53	*Copernicia prunifera* (Mill.) H.E. Moore	Carnaúba		X				X				
54	*Coriandrum sativum* L.	Coentro				X		X				
55	*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson	Eucalipto-limão					X	X				
56	*Costus scaber* Ruiz & Pav.	Cana-do-brejo	X	X								X
57	*Costus spicatus* (Jacq.) Sw.	Cana-do-brejo	X		X							X
58	*Crataegus azarolus* L.	Crataegus			X			X	X			
59	*Crataegus laevigata* (Poir.) DC.	Pilriteiro			X			X	X			
60	*Crataegus monogyna* Jacq.	Pilriteiro			X			X	X			
61	*Crataegus nigra* Waldst. & Kit.	Espinheiro--húngaro			X			X	X			
62	*Crataegus pentagyna* Waldst. & Kit. ex Willd.	Espinheiro-preto			X			X	X			
63	*Crataegus rhipidophylla* Gand.	Espinheiro-alvar			X			X	X			
64	*Croton cajucara* Benth.	Marassacaca		X								X
65	*Croton grewioides* Baill. = *Croton zehntneri* Pax & K. Hoffm.	Alecrim-de-cabloca		X								X
66	*Curcuma longa* L.	Açafrão-da--terra					X	X	X			X
67	*Cymbopogon citratus* (DC.) Stapf	Capim-limão	X			X		X				
68	*Cymbopogon martini* (Roxb.) W. Watson	Palmarosa	X				X	X				
69	*Cynara scolymus* L.	Alcachofra			X			X	X	X	X	X
70	*Dalbergia subcymosa* Ducke	Verônica		X								X
71	*Datura stramonium* L.	Castanheiro--do-diabo				X		X				

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
72	*Dysphania ambrosioides* (L.) Mosyakin & Clemants = *Chenopodium ambrosioides* L.	Erva-de-santa-maria	X			X						X
73	*Echinacea angustifolia* DC.	Equinácea			X				X			
74	*Echinacea purpurea* (L.) Moench	Equinácea			X				X	X		
75	*Echinodorus grandiflorus* (Cham. & Schltdl.) Micheli	Chapéu-de-couro		X				X				
76	*Elettaria cardamomum* (L.) Maton	Cardamomo			X			X				
77	*Equisetum arvense* L.	Cavalinha			X				X	X		
78	*Eucalyptus globulus* Labill.	Eucalipto					X	X	X			
79	*Eugenia uniflora* L.	Pitangueira	X	X				X				
80	*Euphorbia prostrata* Ailton.	Quebra-pedra-rasteiro	X	X								
81	*Euphorbia tirucalli* L.	Quebra-pedra	X				X					
82	*Foeniculum vulgare* Mill.	Funcho	X			X		X	X			
83	*Frangula purshiana* (DC.) A. Gray	Cáscara-sagrada			X			X	X			
84	*Fridericia chica* (Bonpl.) L.G. Lohmann = *Arrabidaea chica* (Bonpl.) Verl.	Crajiru		X								X
85	*Gallesia integrifolia* (Spreng.) Harms	Pau-d'alho	X	X								
86	*Gentiana lutea* L.	Genciana-amarela			X			X				
87	*Ginkgo biloba* L.	Ginkgo-biloba					X			X		
88	*Glycine max* (L.) Merr.	Soja					X		X	X	X	
89	*Glycyrrhiza glabra* L.	Alcaçuz			X			X	X			
90	*Glycyrrhiza inflata* Batalin	Alcaçuz			X				X			
91	*Glycyrrhiza uralensis* Fisch.	Alcaçuz			X				X			
92	*Gossypium hirsutum* L.	Algodoeiro				X		X				
93	*Gymnanthemum amygdalinum* (Delile) Sch.Bip. ex Walp.	Boldo	X			X						X
94	*Hamamelis virginiana* L.	Hamamélis	X		X			X				
95	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos = *Tabebuia avellanedae* Lorentz ex Griseb.	Ipê-roxo		X					X			X

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
96	*Harpagophytum procumbens* DC. ex Meissn.	Garra-do-diabo			X			X	X	X	X	
97	*Harpagophytum zeyheri* Decne	Garra-do-diabo			X			X	X	X		
98	*Helianthus annuus* L.	Girassol					X	X				
99	*Hydrastis canadensis* L.	Hidraste			X			X				
100	*Hyoscyamus niger* L.	Meimendro--negro			X			X				
101	*Hypericum perforatum* L.	Erva-de-são--joão			X				X	X		
102	*Illicium verum* Hook. f.	Anis-estrelado					X	X				
103	*Jatropha gossypiifolia* L.	Pinhão-roxo	X	X								
104	*Jatropha multifida* L.	Flor-de-coral	X				X					
105	*Justicia pectoralis* Jacq.	Chambá		X				X				
106	*Kalanchoe brasiliensis* Cambess.	Saião	X	X								
107	*Krameria lappacea* (Dombey) Burdet & B.B. Simpson	Ratânia-peruana			X			X				
108	*Lavandula angustifolia* Mill.	Alfazema					X	X				
109	*Leonotis nepetifolia* (R.Br.) W.T. Aiton	Cordão-de--frade	X			X						
110	*Leonurus cardiaca* L.	Agripalma			X			X				
111	*Leonurus japonicus* Houtt.	Rubim	X			X						
112	*Libidibia ferrea* (Mart. ex Tul.) L.P. Queiroz = *Caesalpinia ferrea* Mart. ex Tul.	Pau-ferro		X								X
113	*Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson	Cidreira	X	X				X				
114	*Lippia sidoides* Cham. = *Lippia origanoides* Kunth	Alecrim-pimenta		X				X		X		X
115	*Malva sylvestris* L.	Malva			X							X
116	*Mangifera indica* L.	Mangueira	X				X					
117	*Matricaria chamomilla* L.	Camomila	X				X			X		X
118	*Maytenus aquifolia* Mart. = *Monteverdia aquifolia* (Mart.) Biral	Espinheira--santa		X						X		X
119	*Maytenus ilicifolia* Mart. ex Reissek = *Monteverdia ilicifolia* (Mart. Ex Reissek) Biral	Espinheira--santa		X				X		X	X	X
120	*Melaleuca alternifolia* (Maiden & Betche) Cheel	Árvore-do-chá					X	X				

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
121	*Melissa officinalis* L.	Erva-cidreira	X				X	X				
122	*Mentha arvensis* L.	Hortelã-japonesa					X	X				
123	*Mentha crispa* L.	Menta	X			X						X
124	*Mentha pulegium* L.	Poejo	X			X						X
125	*Mentha villosa* Huds.	Hortelã	X		X							X
126	*Mentha x piperita* L.	Menta-piperita	X				X	X			X	X
127	*Mikania glomerata* Spreng.	Guaco	X	X				X			X	X
128	*Mikania laevigata* Sch.Bip. ex Baker	Guaco	X	X				X			X	X
129	*Mimosa pudica* L.	Dormideira	X	X								
130	*Momordica charantia* L.	Melão-são-caetano	X			X						X
131	*Myristica fragrans* Houtt.	Moscadeira			X			X				
132	*Myroxylon balsamum* (L.) Harms var. balsamum	Bálsamo-de-tolu		X				X				
133	*Myroxylon balsamum* (L.) Harms var. pereirae (Royle) Harms	Bálsamo-do--peru		X				X				
134	*Nasturtium officinale* W.T. Aiton = *Rorippa nasturtium-aquaticum* (L.) Hayek	Agrião	X				X					
135	*Ocimum gratissimum* L.	Alfavacão				X						X
136	*Olea europaea* L.	Oliveira					X	X				
137	*Operculina macrocarpa* (L.) Urb.	Batata-de-purga		X				X				
138	*Parietaria officinalis* L.	Parietária	X				X					
139	*Passiflora alata* Curtis	Maracujá	X	X				X				X
140	*Passiflora edulis* Sims	Maracujá-doce	X	X				X				X
141	*Passiflora incarnata* L.	Maracujá	X				X	X		X		X
142	*Paullinia cupana* Kunth	Guaraná		X						X		
143	*Pectis brevipedunculata* (Gardner) Sch. Bip.	Capim-limão--de-flor	X	X								
144	*Persea americana* Mill.	Abacateiro	X			X						X
145	*Petroselinum sativum* Hoffm.	Salsa					X					X
146	*Peumus boldus* Molina	Boldo-do-chile	X		X					X		
147	*Phyllanthus niruri* L.	Quebra-pedra	X	X				X				X
148	*Phyllanthus tenellus* Roxb.	Quebra-pedra	X	X								X

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
149	*Phyllanthus urinaria* L.	Quebra-pedra	X	X								X
150	*Pilocarpus microphyllus* Stapf ex Wardlew.	Jaborandi	X	X								
151	*Pimpinella anisum* L.	Erva-doce	X				X					
152	*Piper anisum* (Spreng.) Angely	Jaborandi	X	X								
153	*Piper methysticum* G. Forst	Kava-kava					X			X		
154	*Plantago major* L.	Transagem				X		X				X
155	*Plantago ovata* Forssk.	Transagem			X						X	
156	*Plectranthus amboinicus* (Lour.) Spreng.	Hortelã-grossa	X				X					
157	*Plectranthus barbatus* Andrews	Boldo-de-jardim	X				X	X				X
158	*Polygala senega* L.	Polígala			X			X				
159	*Polygonum hydropiperoides* Michx.	Erva-de-bicho	X	X								X
160	*Polygonum punctatum* Elliott = *Polygonum acre* Kunth	Erva-de-bicho		X								X
161	*Portulaca pilosa* L.	Amor-crescido		X								X
162	*Prunus domestica* L.	Ameixeira-europeia					X	X				
163	*Psidium guajava* L.	Goiabeira	X			X				X		X
164	*Punica granatum* L.	Romã	X			X		X				X
165	*Quillaja saponaria* Molina	Quilaia			X			X				
166	*Rauwolfia serpentina* (L.) Benth. ex Kurz	Rauwolfia-serpentina			X			X				
167	*Rhamnus purshiana* DC.	Cáscara-sagrada			X					X	X	X
168	*Rheum officinale* Baill.	Ruibarbo-chinês			X			X				
169	*Rheum palmatum* L.	Ruibarbo			X			X				
170	*Rosa alba* L.	Rosa-branca	X				X					
171	*Rosa rubiginosa* L.	Rosa-mosqueta	X				X					
172	*Ruta graveolens* L.	Arruda	X		X							X
173	*Salix alba* L.	Salgueiro-branco					X				X	X
174	*Salix daphnoides* Vill.	Salgueiro-violeta			X			X				
175	*Salix fragilis* L.	Salgueiro-frágil			X			X				

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
176	*Salix purpurea* L.	Salgueiro-de--casca-roxa			X			X				
177	*Salvia officinalis* L.	Sálvia					X	X				
178	*Salvia rosmarinus* Schleid. = *Rosmarinus officinalis* L.	Alecrim					X	X				
179	*Sambucus australis* Cham. & Schltdl.	Sabugueiro	X	X								
180	*Sambucus nigra* L.	Sabugueiro	X			X		X				
181	*Schinus terebinthifolia* Raddi	Aroeira	X	X							X	X
182	*Senna alexandrina* Mill.	Sene				X				X		
183	*Serenoa repens* (W. Bartram) Small	Saw-palmetto			X			X		X		
184	*Silybum marianum* (L.) Gaertn.	Cardo-mariano				X		X				
185	*Solanum paniculatum* L.	Jurubeba		X								X
186	*Solidago chilensis* Meyen = *Solidago microglossa* DC.	Arnica-brasi-leira	X	X								X
187	*Stevia rebaudiana* (Bertoni) Bertoni	Estévia		X				X				
188	*Strychnos nux-vomica* L.	Noz-vómica			X			X				
189	*Stryphnodendron adstringens* (Mart.) Coville	Barbatimão		X						X		X
190	*Styrax benzoin* Dryand.	Benjoeiro			X			X				
191	*Syzygium aromaticum* (L.) Merr. & L.M. Perry	Cravo-da-índia	X				X					
192	*Syzygium cumini* (L.) Skeels	Jamelão				X						X
193	*Tagetes minuta* L.	Cravo-de-de-funto				X						X
194	*Tanacetum parthenium* (L.) Sch.Bip.	Tanaceto					X	X				
195	*Taraxacum officinale* F.H. Wigg.	Dente-de-leão	X			X		X				
196	*Theobroma cacao* L.	Cacau				X		X				
197	*Thymus vulgaris* L.	Tomilho					X	X				
198	*Trifolium pratense* L.	Trevo-dos-pra-dos				X		X		X		X
199	*Uncaria tomentosa* (Willd. ex Roem. & Schult.) DC.	Unha-de-gato		X				X		X	X	X
200	*Vaccinium macrocarpon* Aiton	Arando			X			X				
201	*Valeriana officinalis* L.	Valeriana					X	X		X		

Nº	Scientific Name	Common Name	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
202	*Vanilla planifolia* Jacks. ex Andrews	Baunilha		X				X				
203	*Varronia curassavica* Jacq. = *Cordia curassavica* (Jacq.) Roem. & Schult.	Erva-baleeira		X								X
204	*Vernonanthura polyanthes* (Sprengel) Vega & Dematteis	Assa-peixe	X	X								X
205	*Vernonanthura membranacea* (Gardner) H. Rob. = *Vernonia ruficoma* Gardner	Assa-peixe	X	X								X
206	*Vitex agnus-castus* L.	Vitex				X		X				
207	*Zea mays* L.	Milho					X	X				
208	*Zingiber officinale* Roscoe	Gengibre	X				X	X		X		X
209	*Ziziphus joazeiro* Mart.	Joazeiro	X	X								

Sources Researched: FB: Brazilian Pharmacopoeia (6th edition), FFFB: Brazilian Pharmacopoeia Herbal Medicines Form (1st edition - First Supplement), MFFB: Herbal Medicine Memento of the Brazilian Pharmacopoeia, Rename: National List of Essential Medicines, Renisus: National List of Medicinal Plants of Interest to the Unified Health System (SUS).

Subtitle: Cit: *Medicinal species that have a popular name identical to those mentioned by the informants,* **Na:** *Native species,* **Ex:** *Exotic species,* **Nat:** *Naturalized species,* **Cul:** *Cultivated species.*

The National Policy on Medicinal Plants and Herbal Medicines (PNPMF) advises intensifying research and developing new technologies in native and exotic medicinal plants adapted from the Brazilian flora and sustainably using them (BRASIL, 2016).

Within this context, guideline 5 prioritises the epidemiological needs of the population. In contrast, sub guideline 7.3 encourages research to increase the number of native species of the Brazilian flora in the Brazilian Pharmacopoeia (BRASIL, 2016).

The plant species listed above (Table 4) fit the biodiversity profiles that the PNPMF suggests for the development of research and the rational use of species already studied.

The general list meets the objective developed by the technical staff of CRS/JBRJ, which uses plant species with medicinal properties in a space that adds human resources training and permeation of sociocultural values to current therapeutic needs.

Each species has a history, which can be worked on during and after implementing Pais social technology.

The National Policy on Integrative and Complementary Practices (PNPIC) has perspectives similar to the PNPMF; this can be seen through the PMF7 (Medicinal Plants and Phytotherapy) guideline because it talks about encouraging research and technological developments based on the traditional use of medicinal species, prioritising the epidemiological needs of the population with an emphasis on native species (BRASIL, 2015).

The general list presented in Table 4 aligns with the two public policies PNPMF and PNPIC, because most of the medicinal species listed are native and exotic cultivated in the Brazilian territory. In addition, there

was the participation of the local population that indicated native species with traditional uses, such as – *A. brasiliana*, *B. dracunculifolia*, *B. trimera*, *B. alba*, *B. orellana*, *C. ficifolia*, *E. uniflora*, among others.

It is essential to emphasise the relevance of the Pais social technology precepts, which follow an agroecological cultivation pattern capable of grouping different species in a single location. Therefore, it is ideal for deployment in the socio-environmental sector of Ciampa, as the site has space to receive a large number of plant species.

The vision and mission of Ciampa's socio-environmental sector are compatible with sustainability objectives through the reforestation activities carried out in the degraded areas of the surroundings. And the structuring of this crop creates an unprecedented opportunity to develop teaching and research activities in the agroecological area with medicinal plants.

3.4 ADAPTATION OF SWOT-AHP METHODOLOGY

The Swot-AHP methodology adapted to this work identified the strengths and weaknesses of the strategic and operational system of the socio-environmental sector in an integrated manner (FORMIGA JR.; CÂNDIDO; AMARAL, 2015). It was able to originate new methodological paths.

Figure 4 shows the management strategies used to structure and compile medicinal species with cultural importance, added with medicinal species that have national significance for the Ministry of Health (MS).

Figure 4 | Methodological steps focus on the structuring and compiling of medicinal species to implement a social technology involving cultivation.

Source: A self elaboration.

4 FINAL CONSIDERATIONS

The Swot-AHP method played a vital role in developing activities in Ciampa's socio-environmental sector and organising the necessary paths for implementing sustainable cultivation based on the technology of Integrated and Sustainable Agroecological Production (Pais).

This methodology is applicable in the environmental area. It must be part of the management of the socio-environmental sector to develop the activities necessary for the sector's growth, especially the development of Pais social technology with medicinal plants.

One of the main factors clarified so far concerns the identification of strategic and fundamental points the need to implement a fundraising team and another to implementation of projects, highlighting the selection of medicinal species of national public interest, taking into account local traditional knowledge, to compose the future structure made with Pais social technology.

The next step is the choice of species through the general list to build the design of the mandala beds based on the particularities of cultivation of each species. Within this context, the idea is that biomes group the species to develop educational activities on naturalised and cultivated native and exotic Brazilian biodiversity.

The implantation of an agroecological crop in the socio-environmental sector of Ciampa depends on the completion of the gardening course, the voluntary support of the local community proposed by the coordinator, and the technical support of CRS/JBRJ. These are great opportunities that must be worked on at the beginning of the cultivation's implantation and the continuity of activities in the sector.

Thanks to the adaptation of the Swot-AHP method to the present work, it was possible to organise absolute paths for the development of jobs in the area of sustainability that have the purpose of

managing or setting up an environmental sector based on the cultivation of medicinal plants.

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Produção agroecológica integrada e sustentável para plantas medicinais: uma proposta a partir da gestão estratégica

Integrated and sustainable agroecological production for medicinal plants: a proposal based on strategic management

Jeferson Adriano e Silva Assunção [1]

Ygor Jessé Ramos dos Santos [2]

João Carlos da Silva [3]

Nina Cláudia Barboza da Silva [4]

Danilo Ribeiro de Oliveira [5]

[1] Mestre em Ciência e Tecnologia Farmacêutica, Professor, Centro de Responsabilidade Socioambiental do Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brasil
E-mail: jefersonadriano.sa@gmail.com

[2] Mestre em Biologia Vegetal, Assessor técnico laboratorial e Professor, Centro de Responsabilidade Socioambiental do Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brasil
E-mail: ygorjesse@jbrj.gov.br

[3] Mestre em Avaliação, Coordenador, Centro de Responsabilidade Socioambiental do Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brasil
E-mail: jcsilva@jbrj.gov.br

[4] Doutora em Biotecnologia Vegetal, Professora Associada II, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil
E-mail: ninacbs@gmail.com

[5] Doutor em Química de Produtos Naturais, Professor Associado, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil
E-mail: danilopharma@gmail.com

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ARTICLE – VARIA

RESUMO

Foi proposto um plano de gestão baseado na tecnologia de Produção Agroecológica Integrada e Sustentável (Pais) para cultivo de plantas medicinais, por meio de um estudo de caso. Adotou-se a técnica Swot-AHP para avaliar problemas no cultivo agroecológico, indicando etapas do trabalho de

implantação, antes da estruturação física do projeto, integrado a uma ação social participativa com funcionários da instituição que revelaram uso de 64 plantas medicinais, destacando-se boldo, capim-limão e erva-cidreira, enquanto 174 espécies vegetais foram levantadas em documentos oficiais brasileiros. A falta de eletricidade e o atraso da verba pelos financiadores são os maiores problemas, enquanto o espaço para trabalho e curso de jardinagem são as melhores potencialidades. Por meio da integração desses dados, foi proposta a implantação de equipes para captação de recursos e para implantação de projetos, tendo por base uma lista de espécies medicinais para compor a futura estrutura feita com tecnologia social Pais.

Palavras-chave: Gestão estratégica. Swot-AHP. Agroecologia. Cultivo. Plantas medicinais.

ABSTRACT

A management plan based on Integrated and Sustainable Agroecological Production (Pais) technology for the cultivation of medicinal plants, through a case study. The Swot-AHP technique was adopted to evaluate problems to agroecological cultivation, indicating stages of the implementation work, before the physical structuring of the project, integrated with a participative social action with employees of the institution who revealed the use of 64 medicinal plants, highlighting boldo, lemongrass, and lemon balm, while 174 plant species were identified in official Brazilian documents. The lack of electricity and funding delays by funders are the most significant problems, while the space for work and gardening courses are the best potential. The integration of these data has proposed the implementation of teams for fundraising and project implementation, based on a list of medicinal species to compose the future structure made with Pais social technology.

Keywords: Strategic management. Swot-AHP. Agroecology. Cultivation. Medicinal plants.

1 INTRODUÇÃO

O cultivo orgânico é utilizado na agroecologia, a qual é entendida como a união dos conhecimentos tradicionais às diferentes ciências, com o objetivo de desenvolver modelos de agricultura ecologicamente sustentáveis, economicamente viáveis e socialmente justos (ALTIERI, 2004).

A partir dos avanços feitos com os modelos agroecológicos para cultivo e produção vegetal com respeito ao meio ambiente, em 1999, o engenheiro agrônomo Aly Ndiaye idealizou, com uma família de agricultores rurais de Petrópolis, no Rio de Janeiro, um sistema de cultivo denominado Produção Agroecológica Integrada e Sustentável (Pais). Essa estratégia tinha como objetivo exercer a inclusão social, a segurança alimentar, o combate à fome e à pobreza extrema, como também a implementação de novos hábitos alimentares saudáveis para comunidades de baixa renda por meio da integração de vegetais e animais sem o uso de agrotóxicos, seguindo o conceito agroecológico (NDIAYE, 2016).

A tecnologia social Pais trouxe a proposta de uma mandala em formato circular, integrando as espécies vegetais (hortaliças, aromáticas e condimentares) com um galinheiro central e/ou um tanque com peixes para que fosse possível utilizar as fezes das aves ou dos peixes para a adubação, e os restos dos vegetais para a alimentação desses animais. A partir da disponibilização de todos os materiais e insumos necessários para a montagem dessa tecnologia de cultivo agroecológico, além de consultorias técnicas por 30 meses, diversos sistemas foram implantados no território nacional, principalmente em pequenas propriedades rurais, com o objetivo de agregar segurança e soberania alimentar, como também geração de renda (NDIAYE, 2016; SEBRAE, 2008).

No entanto, ainda existem poucos resultados sobre a sistematização de dados para a construção dessa tecnologia social (SILVA *et al.*, 2018).

A análise da matriz *Swot* (*Strengths, Weaknesses, Opportunities e Threats*), também conhecida no Brasil como matriz Fofa (Forças, Fraquezas, Oportunidades e Ameaças), é uma técnica preventiva de aplicação, principalmente em início de pesquisas e empreendimentos, com o propósito de minimizar os problemas futuros. Pode auxiliar no processo de sistematização de dados, uma vez que tanto relaciona os fatores internos – forças e fraquezas –, como também os fatores externos – oportunidades e ameaças –, o que facilita a análise das condições que podem influenciar de forma negativa e positiva antes de iniciar o processo de estruturação de um determinado projeto, promovendo segurança nas ações futuras (SOUSA *et al.*, 2019).

De caráter qualitativo, *Swot* é excipiente para muitas aplicações, tais como: administração geral de empresas, *marketing* e mercado, cuidados da saúde, cosmético, aprendizagem e educação, agricultura, silvicultura, meio ambiente, medicina e farmácia, indústria têxtil, turismo, manufatura, transporte, biblioteca, construção, petróleo e gás, forças armadas, mercado financeiro, entre outros (GHAZINOORY; ABDI; AZADEGAN-MEHR, 2011). Kurttila e colaboradores (2000), observando esse gargalo, propuseram a união da análise de *Swot* com uma técnica quantitativa denominada de *Analytic Hierarchy Process* (*AHP*).

Para a realização desse método híbrido (*Swot-AHP*), foram estabelecidas etapas como a realização da análise de *Swot*, comparações pareadas entre fatores *Swot* realizadas em todos os grupos dentro da análise de *Swot*, comparações aos pares entre os quatro grupos dentro da matriz de *Swot* e a utilização dos resultados no processo de formulação e avaliação da estratégia (GHAZINOORY; ABDI; AZADEGAN-MEHR, 2011).

Diante desse panorama, este trabalho teve como objetivo aplicar uma ferramenta para construção de um plano de gestão estratégica com a análise *Swot-AHP* para a seleção e o cultivo de plantas com propriedades medicinais, baseado na tecnologia de Pais por meio de um estudo de caso.

2 PROCEDIMENTOS METODOLÓGICOS

2.1 LOCAL DE ESTUDO

O Centro de Instrução Almirante Milcíades Portela Alves (Ciampa) ocupa uma área de 4.500.000 m² e localiza-se no Complexo Naval Guandu do Sapê, às margens da Avenida Brasil, no bairro do Campo Grande, no Rio de Janeiro, abrigando a Empresa Gerencial de Projetos Navais (Emgepron), vinculada ao Ministério da Defesa (MOTA, 2008). A Emgepron é responsável pela produção de munição e pelo Programa Socioambiental e Adequação Ecológica do Complexo Naval Guandu do Sapê (EMGEPRON, 2017).

2.2 PROPOSIÇÃO DO PROCESSO DE GESTÃO

Após análise estrutural do setor socioambiental do Ciampa, foi desenvolvida a análise de *Swot*, enumerando os pontos positivos e negativos, pela qual se pôde identificar os fatores internos e externos para gerar matrizes qualiquantitativas (SOUSA *et al.*, 2019).

A entrevista inicial realizada com o coordenador de projetos ambientais do Ciampa enumerou todos os fatores internos e externos do setor socioambiental diante da implantação da tecnologia social Pais (ABE; MIRAGLIA, 2020). A partir desse *checklist*, foi elaborado um quadro com as informações, utilizando o *software* de criação de fluxogramas e diagramas Lucidchart.

A partir das informações qualitativas (análise de *Swot)*, foram realizadas as análises quantitativas (*AHP)* para classificar as relações. Essa classificação categoriza as informações em uma escala de 0 a 3: sem nenhuma relação (0); relação fraca (1); relação moderada (2); e relação forte (3) (KURTTILA *et al.*, 2000).

Foram geradas duas matrizes 9x9 na classificação das relações, nas quais a primeira matriz numera a relação das informações e soma cada coluna e linha, e a segunda matriz expõe todas as relações fortes, com divisões em eixos temáticos prioritários para alcançar a resolução dos problemas.

Este trabalho construiu um estudo de caso investigativo com características metodológicas qualiquantitativas (GIL, 2008), por meio de observação não participante e entrevistas semiestruturadas, bem como o aproveitamento máximo das respostas, considerações e comentários obtidos (FORMIGA JÚNIOR; CÂNDIDO; AMARAL, 2015).

2.3 SELEÇÃO ESTRATÉGICA DE ESPÉCIES MEDICINAIS

As espécies medicinais foram selecionadas a partir de documentos normativos vigentes que norteiam a pesquisa e/ou uso de plantas medicinais e fitoterápicos no âmbito do governo federal: *Farmacopeia Brasileira – 6ª ed.* (2019) (FB), *Formulário de Fitoterápicos da Farmacopeia Brasileira* (2018) (FFFB), *Memento Fitoterápico da Farmacopeia Brasileira* (2016) (MFFB), *Relação Nacional de Medicamentos Essenciais* (2018) (Rename) e *Relação Nacional de Plantas Medicinais de Interesse ao SUS* (2009) (Renisus).

2.3.1 ENTREVISTAS E ÍNDICE DE SALIÊNCIA (IS)

Ocorreram duas reuniões com funcionários do Ciampa que possuem conhecimento sobre plantas medicinais, a fim de explicar sobre a intenção da participação social na escolha das espécies medicinais para compor a estrutura a ser feita com a tecnologia social Pais.

Diante desse contexto, realizaram-se entrevistas semiestruturadas com auxílio de um questionário dividido em duas partes: perguntas de caráter socioeconômico e perguntas relacionadas às plantas medicinais (nome popular, indicações de uso popular e local de obtenção).

A lista das plantas medicinais citadas nas entrevistas (lista livre) foi processada a fim de calcular o Índice de Saliência (IS) com auxílio da ferramenta Anthropac 4.983 (*Analytic Technologies*, *USA*) (ALBUQUERQUE *et al.,* 2014).

As plantas medicinais calculadas por meio do IS foram cruzadas com a lista feita atendendo às principais normativas publicadas pelo Ministério da Saúde.

Devido à impossibilidade de coleta para a identificação das plantas medicinais citadas pelos informantes, utilizou-se a técnica denominada “pistas taxonômicas” para encontrar os nomes científicos das espécies vegetais citadas. Essa técnica tem por finalidade equiparar os nomes populares das plantas medicinais citadas com as espécies vegetais nomeadas cientificamente na literatura (BOCHNER *et al.*, 2012). A nomenclatura científica foi atualizada por meio da lista da *Flora do Brasil* (2020), *Tropicos* (2020) e *The Plant List* (2013).

A presente pesquisa foi aprovada em Comitê de Ética, Parecer CEP/HUCFF/FM/UFRJ n.º 3.234.966. Todos os informantes assinaram Termo de Consentimento Livre e Esclarecido (TCLE), dando prévia ciência e autorização para coleta e o uso dos dados levantados.

Os dados obtidos foram organizados em tabelas, analisados e apresentados na forma de gráficos preparados com o auxílio do programa Excel®.

3 RESULTADOS E DISCUSSÃO

3.1 PROPOSIÇÃO DO PROCESSO DE GESTÃO

3.1.1 ANÁLISE QUALITATIVA

A partir das análises das entrevistas com o coordenador do setor socioambiental, foi possível construir o quadro com a análise de *Swot*. Foram levantados 18 fatores internos e externos, os quais se relacionam com a futura implantação da tecnologia social Pais.

Esses fatores listados na análise de *Swot* (Figura 1) ajudaram a construir cenários futuros e estratégias de ação capazes de anular ou mitigar possíveis interferências na execução de um cultivo sustentável nos moldes da tecnologia social Pais, portanto a visualização de todos os fatores de influência positiva e negativa elencados consolida o entendimento das ideias mais benéficas de modo a fortalecer os atributos do cultivo (OLIVAL, 2016).

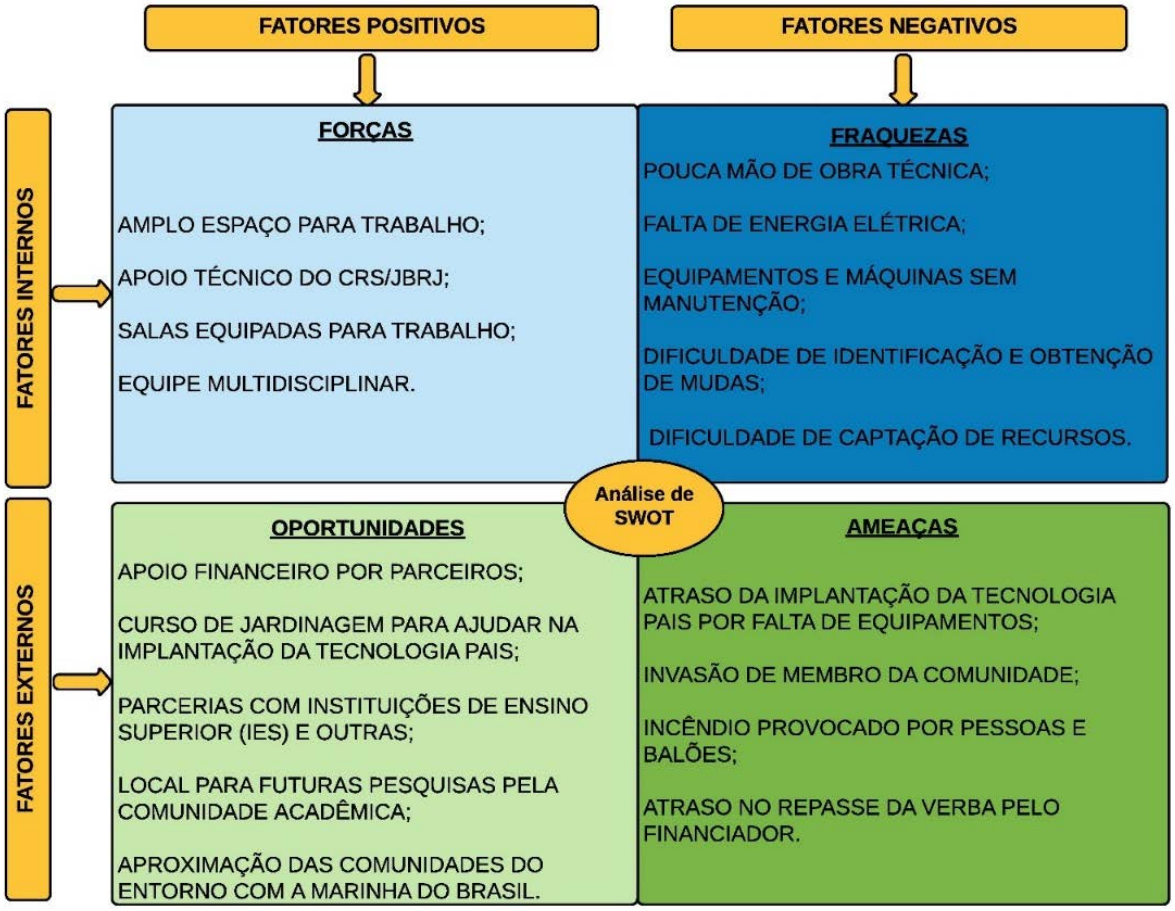

Figura 1 | Análise de Swot elaborada a partir dos principais fatores negativos e positivos relacionados com a implantação da tecnologia social Pais no Complexo Naval da Marinha do Brasil de Campo Grande/RJ.

Fonte: Elaboração própria com base em Kurttila et al. (2000).

- Fraquezas e ameaças

Por meio da análise das ações, foram encontrados importantes desafios descritos como fraquezas, são elas: “pouca mão de obra técnica”, “falta de energia elétrica”, “equipamentos e máquinas sem manutenção”, “dificuldade para identificação e obtenção de mudas” e “dificuldade de captação de recursos”.

Essas fraquezas são as ações relacionadas à falta de repasse de verba, principalmente para as três primeiras mencionadas acima. Segundo o gestor do setor socioambiental do Ciampa, a verba do programa socioambiental é menor do que a previsão feita por ele, e, por consequência, as fraquezas podem sofrer atraso na resolução ou não serem resolvidas por questão de prioridade.

As ameaças podem acontecer ou não, isso vai depender do grau de relação entre ameaças x oportunidades, ameaças x forças e ameaças x fraquezas, calculado na classificação das relações.

O atraso no repasse de verbas pelo financiador e o atraso da implantação da tecnologia social Pais por falta de equipamentos estão intimamente ligados, uma vez que, para a execução física do cultivo, é necessário adquirir ferramentas, espécies vegetais e material para o plantio. Dessa maneira, buscar recursos financeiros de outros lugares ou formar parcerias com outras instituições são alternativas relevantes para prevenir essas ameaças.

A invasão de pessoas da comunidade local não gera perigo para o cultivo, visto que a área pertence ao corpo militar da Marinha do Brasil e essa invasão ocorre por causa de animais, como cavalos e bois, que fogem para dentro do Ciampa, por consequência seus donos entram para resgatá-los.

No caso de incêndios provocados por pessoas e balões, há uma solução já utilizada. A área é dividida por pequenas estradas sem vegetações que servem para controlar um possível foco de incêndio.

Diante dessa análise de *Swot*, sabe-se que os modelos alternativos de produção possuem desafios (ameaças e fraquezas) importantes a serem superados, para que ocorra sucesso na implantação e sustentação de projetos agroecológicos. Por isso, deve haver diálogo e aprendizagem coletiva (SANTO; GOMES; PIRES, 2019) e, portanto, essa análise deve ser permanente, a fim de reunir a equipe para discutir em grupo as soluções disponíveis, com o propósito de avaliar e tomar decisões que busquem a conciliação das ações necessárias ao desenvolvimento e elaboração das metas (KLOCK; MARINI; GODOY, 2019).

- Forças e oportunidades

As forças mostram que a parte estrutural é preparada para receber um projeto de grande porte, pois existe um amplo espaço para trabalho com salas equipadas, além de contar com a equipe multidisciplinar do Centro de Responsabilidade Socioambiental do Jardim Botânico do Rio de Janeiro (CRS/JBRJ), por meio de um acordo de cooperação técnica.

As forças e as oportunidades podem ampliar o sucesso do projeto, mitigando grande parte dos pontos fracos, porque ocorre a possibilidade de diversificar as fontes financiadoras, ou seja, buscar nas redondezas do Ciampa apoio de indústrias e instituições que pactuam com projetos ambientais. Além disso, o curso de jardinagem voltado para a comunidade local e as parcerias com Instituições de Ensino Superior (IES) farão parte da inserção de mão de obra e a entrada de recursos financeiros para auxiliar na implantação da tecnologia social Pais.

As forças e as oportunidades trouxeram basicamente a visualização das possibilidades capazes de enfrentar as fraquezas e as ameaças que podem prejudicar a construção da tecnologia social Pais. A análise de *Swot* é uma ferramenta decisiva apenas para a parte qualitativa desse projeto e de outros autores que realizaram estudos de gestão estratégica com plantas medicinais (SILVA *et al.*, 2017; SINGH *et al.*, 2019).

De acordo com a literatura, pôde-se observar que a maior parte dos estudos científicos constrói matrizes de Swot relacionando as forças, as oportunidades, as fraquezas e as ameaças sem avaliar de forma quantitativa a relação dos fatores positivos e negativos presentes (SILVA et al., 2017; MIRANDA et al., 2018).

3.1.2 ANÁLISE QUANTITATIVA

Os fatores negativos e positivos foram agrupados por meio da matriz *Swot*, o que gerou um panorama de todas as ações que auxiliam e prejudicam a estruturação da tecnologia social Pais. Já a análise quantitativa agrupou os principais fatores negativos e positivos para hierarquizar as tomadas de decisão referentes aos problemas de maior à menor importância (fraquezas e ameaças) e os maiores e menores pontos positivos (forças e oportunidades).

A partir da primeira matriz que expõe o somatório de cada coluna e linha da classificação das relações, foi possível identificar dois fatores negativos pontuais: falta de energia elétrica (22 pontos) e atraso no repasse da verba pelos financiadores – 23 pontos (Tabela 1). Essas ações podem impedir inicialmente a estruturação da tecnologia social Pais.

Por outro lado, pôde-se verificar duas ações positivas que mais pontuaram: amplo espaço para trabalho (21 pontos) e o curso de jardinagem para ajudar na implantação da tecnologia social Pais (23 pontos). Com esse curso, é possível minimizar os impactos gerados pelo atraso de verba, pois haverá mão de obra para dar andamento às ações de estruturação da tecnologia social Pais; já a respeito da falta de energia elétrica, é imprescindível solucionar esse problema para que as atividades ocorram naturalmente. Desse modo, a solução para a falta de energia elétrica é a consolidação de uma equipe de captação de recursos, fato verificado na Tabela 2.

Tabela 1 | Matriz quantitativa da análise Swot-AHP com o somatório dos fatores positivos e negativos de maior relevância para a implantação da tecnologia social Pais no Ciampa.

		FORÇAS				FRAQUEZAS					
		Amplo espaço para trabalho	Salas equipadas para trabalho	Equipe multidisciplinar	Apoio técnico do CRS/JBRJ	Pouca mão de obra técnica	Falta de energia elétrica	Equipamentos e máquinas sem manutenção	Dificuldade de identificação e obtenção de mudas	Dificuldade de captação de recursos	TOTAL DE PONTOS
OPORTUNIDADES	Apoio financeiro por parceiros	1	1	2	1	3	3	3	2	3	19
	Curso de jardinagem para ajudar na implantação da tecnologia social Pais	3	2	2	2	3	3	3	2	3	23
	Parcerias com (IES) e outras	3	2	2	1	2	2	1	2	3	18
	Local para futuras pesquisas pela comunidade acadêmica	3	2	2	1	2	3	1	2	3	19
	Aproximação das comunidades do entorno com a Marinha do Brasil	3	2	2	1	2	3	0	0	0	13
AMEAÇAS	Atraso na implantação da tecnologia social Pais por falta de equipamentos e insumos	2	2	2	1	2	3	3	0	3	18
	Atraso no repasse da verba pelo financiador	3	2	2	3	3	3	3	1	3	23
	Invasão de membros da comunidade	0	1	0	0	0	0	0	0	0	1
	Incêndio provocado por pessoas e balões	3	3	1	0	2	2	3	0	2	15
	TOTAL DE PONTOS	21	17	15	10	19	22	17	9	20	

Fonte: Elaboração própria com base em Kurttila et al. (2000) e Chang & Huang (2006).

Baseado no atraso ou na falta de repasse de recursos financeiros, a falta de energia elétrica tem maior destaque porque impacta as atividades a serem realizadas. Diante desse contexto, Rosa (2016) explica que a energia elétrica faz parte do cotidiano dos indivíduos, tanto nos ambientes públicos quanto no trabalho. Essa modificação nos padrões sociais de consumo das populações refletiu na conformação dos padrões de vida da sociedade que hoje depende do uso da eletricidade. A autora destaca que a problemática do acesso à eletricidade se dá pela falta de acesso a esse serviço e não pelo caso de interrupção do acesso, por conta da ineficácia de políticas públicas no sentido de tornar obrigatório o acesso à energia elétrica.

As análises de Miranda e colaboradores (2018) corroboram a fraqueza e a ameaça de maior relevância aqui apresentada, portanto, a gestão pública depende de recursos financeiros para resolver problemas estruturais. É imprescindível o repasse de verba para a melhoria e qualidade dos serviços a serem realizados. Miranda e colaboradores (2018) destacam também a importância da formação de parcerias com a comunidade do entorno nas atividades exercidas no espaço público, que, de certa forma, ajudam a desenvolver atividades não realizadas por falta do repasse de recursos financeiros.

O apoio voluntário de membros das instituições de ensino e de empresas parceiras, junto à consolidação do curso de jardinagem, tem papel importante, como suprir parte da necessidade de pessoal para elaboração da estrutura Pais, bem como contribuir para o desenvolvimento profissional e pessoal dos indivíduos. Por consequência, a repartição pública adquire desenvolvimento em diversas tarefas que o Estado não consegue suprir. Com isso, os laços entre a sociedade e os órgãos públicos são estreitados (BARELI; SOUSA, 2015).

O curso de jardinagem e o apoio voluntário terão a participação de membros das comunidades do entorno, bem como do público em geral. Alguns dos funcionários e estagiários do Ciampa que foram entrevistados e moram nas proximidades manifestaram interesse em aperfeiçoar seus conhecimentos na área de cultivo de plantas. Já ocorreram cursos de jardinagem no setor socioambiental do Ciampa e há interesse pelo retorno dessas atividades, inclusive o coordenador conhece o presidente da associação da comunidade mais próxima denominada Parque São Francisco, possibilitando contato para a divulgação das atividades propostas.

Na Tabela 2, as relações fortes (3) foram capazes de mostrar a necessidade de introduzir no setor socioambiental do Ciampa uma equipe para implantação de projetos e uma equipe para captação de recursos, que serão norteadoras e darão suporte para o andamento e a sustentação do projeto.

Tabela 2 | Matriz quantitativa da análise Swot-AHP com destaque para as relações fortes (3), para que seja possível evidenciar as equipes necessárias para o andamento da implantação da tecnologia social Pais no Ciampa.

Equipe para implantação de projetos

Equipe para captação de recursos

		FORÇAS				FRAQUEZAS				
		Amplo espaço para trabalho	Salas equipadas para trabalho	Equipe multidisciplinar	Apoio técnico do CRS/JBRJ	Pouca mão de obra técnica	Falta de energia elétrica	Equipamentos e máquinas sem manutenção	Dificuldade de identificação e obtenção de mudas	Dificuldade de captação de recursos
OPORTUNIDADES	Apoio financeiro por parceiros					3	3	3		3
	Curso de jardinagem para ajudar na implantação da tecnologia social Pais	3				3	3	3		3
	Parcerias com IES e outras	3								3
	Local para futuras pesquisas pela comunidade acadêmica	3					3			3
	Aproximação das comunidades do entorno com a Marinha do Brasil	3					3			
AMEAÇAS	Atraso na implantação da tecnologia social Pais por falta de equipamentos e insumos						3			3
	Atraso no repasse da verba pelo financiador	3			3	3	3	3		3
	Invasão de membros da comunidade									
	Incêndio provocado por pessoas e balões	3	3					3		

Fonte: Elaboração própria com base em Kurttila et al. (2000).

Santos, Negrão e Saboya (2018) esclarecem que mudanças na gestão pública e/ou falta de recursos financeiros geram o cancelamento ou atraso no repasse do dinheiro às instituições que necessitam disso para sobreviver. No entanto, os autores enfatizam a importância de uma boa gestão estratégica focada na captação e gestão dos recursos financeiros, a fim de administrar o dinheiro de forma equilibrada dentro da instituição.

O setor socioambiental do Ciampa possui o coordenador para executar a gestão, que vai desde a parte dos recursos humanos à parte financeira, ou seja, assume diversos papéis como gestor e sobrecarrega as tarefas diárias. Sabe-se que, para o projeto dar os primeiros passos de estruturação, é necessário contratar pessoal qualificado para ajudá-lo, principalmente nos eixos de captação de recursos e de implantação.

O eixo de implantação pode ser executado de três formas: a primeira opção por meio do acordo de cooperação técnica com o CRS/JBRJ, trazendo seus profissionais e estagiários para auxiliar na estruturação do projeto, com os voluntários da comunidade do entorno, a fim de suprir as necessidades da falta de pessoal para realizar o trabalho manual. Já a segunda opção depende da captação de recursos, ou seja, será necessário aumentar o quadro de pessoal qualificado no setor socioambiental do Ciampa, pois a falta de profissionais nesse setor é um dos principais problemas relatados pelo coordenador.

A terceira opção tem como alternativa a participação social focada no desenvolvimento das atividades do setor socioambiental do Ciampa. Essa alternativa corrobora as conclusões de Petrus, Kátia e Pereira Júnior (2016), os quais esclarecem que a participação social implantada corretamente gera crescimentos econômico, social e político do local.

Outra alternativa que vai auxiliar o desenvolvimento das atividades de forma sustentável é realizar a estruturação da tecnologia social Pais com materiais encontrados no Ciampa. As caixas plásticas que carregam as munições são descartadas e podem ser reaproveitadas para elaboração de canteiros, bem como as estacas das árvores de sansão-do-campo (*Mimosa caesalpiniifolia* Benth.), as quais estão inseridas em uma grande área dentro do Ciampa.

A construção dessa tecnologia social Pais vai gerar interação didática com o público-alvo (instituições de ensino e pesquisa, e pessoas interessadas), insumos à base de plantas medicinais para o uso dos funcionários e programas que trabalham com fitoterapia, produção de mudas certificadas para doação, bem como a realização de um cultivo orgânico com diversas espécies vegetais em um local que sofreu desmatamento.

3.2 PARTICIPAÇÃO SOCIAL NA SELEÇÃO DE ESPÉCIES MEDICINAIS

A primeira reunião, realizada no dia 22 de maio de 2019, teve a participação de 14 funcionários indicados pelo coordenador e o jardineiro mais experiente do setor socioambiental do Ciampa. Nos dias seguintes, 11 funcionários aceitaram fazer uma entrevista semiestruturada.

De acordo com as entrevistas feitas, pôde-se perceber que os dois setores (socioambiental e fábrica) somam a maior porcentagem sob a perspectiva do local onde os informantes veem as espécies medicinais que conhecem e utilizam (Figura 2), mostrando a relevância principalmente do setor socioambiental na construção do conhecimento das plantas medicinais.

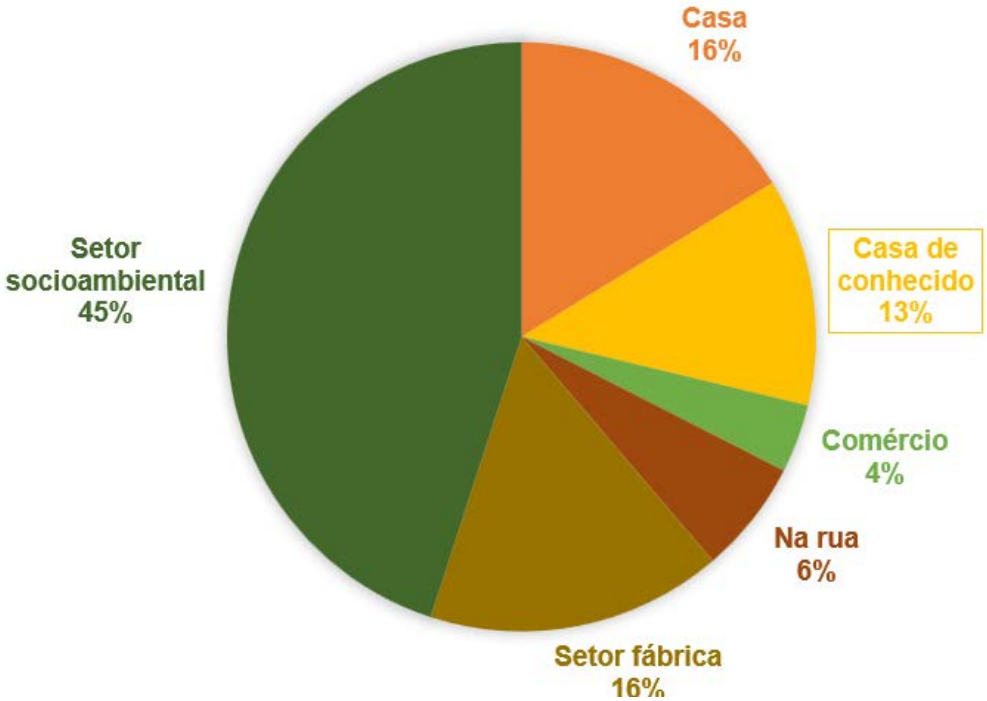

Figura 2| Localização das plantas citadas nas entrevistas com os informantes do Ciampa.

Source: Authors

O estudo de Faria e Albuquerque (2018) sobre os fatores socioeconômicos que podem afetar o conhecimento de plantas medicinais esclarece que o contato frequente com essas plantas influencia positivamente o

conhecimento da população participante da pesquisa. Essa conclusão corrobora este trabalho, pelo fato de que o ambiente de trabalho dos informantes do Ciampa possui os dois locais com maiores porcentagens de citação, ou seja, grande parte das plantas que eles conhecem é cultivada no local de trabalho.

Um dos fatores que contribuem para o conhecimento dos informantes é o fato de que o Ciampa possui uma extensa área verde, por integrar a Serra Marapicu-Gericinó-Mendanha (MGM), a qual possui, em grande parte, uma vegetação de Mata Atlântica nativa. Boa parte desse local, portanto, é uma Área de Proteção Ambiental (APA) (MOTA, 2008).

Essa extensa área verde fica ao redor dos dois setores: socioambiental e fábrica. No primeiro, ocorre o reflorestamento e os estudos das áreas degradadas dentro do Ciampa, que, dessa forma, contribui para o conhecimento sobre plantas medicinais e demais plantas não medicinais, levando em conta que a maioria dos informantes relatou ter pouco espaço para plantio em suas residências.

Foram mencionadas 64 plantas medicinais, as quais totalizam 119 citações. Diante das análises feitas com todas as plantas, o boldo se destacou por ter sido citado por oito informantes (72,7%), seguido por capim-limão e erva-cidreira com seis citações cada (54,5%) (Figura 3).

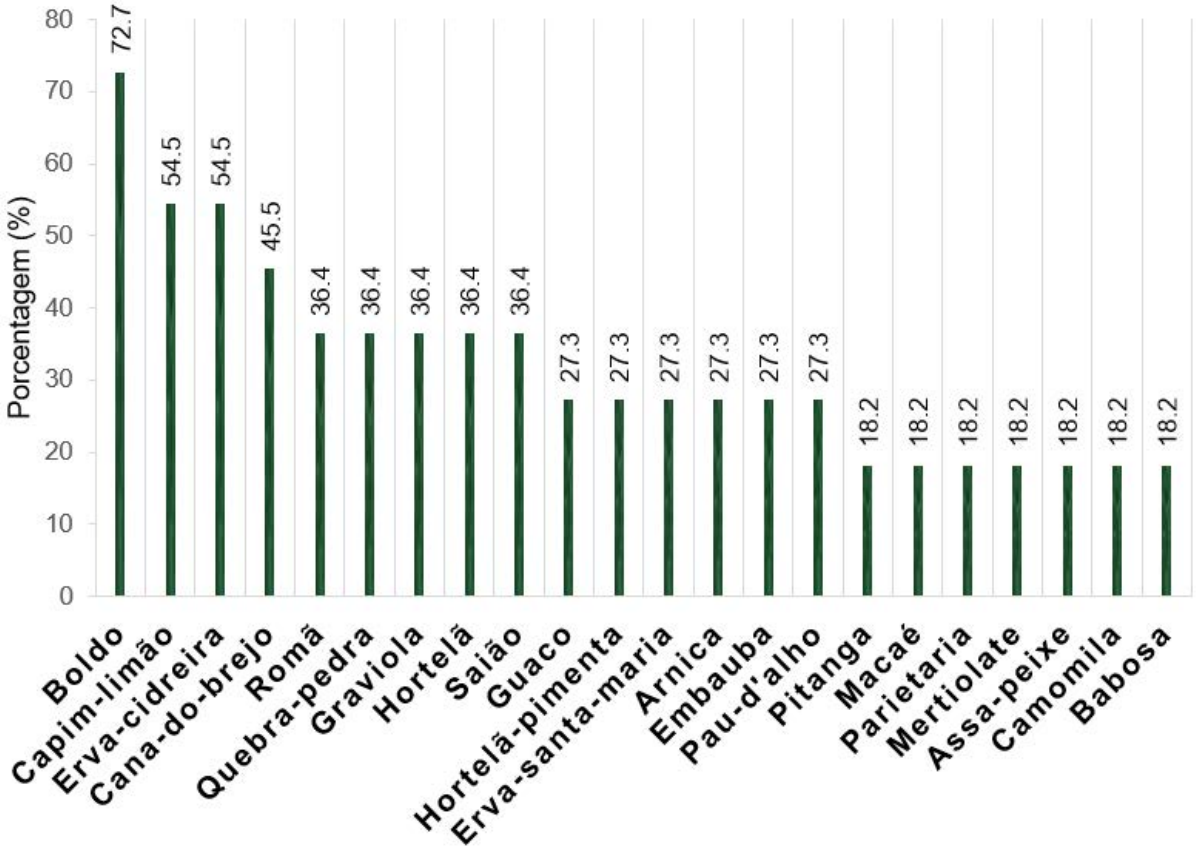

Figure 3 | Frequency of citations of plants was obtained through interviews carried out with informants from the Ciampa. Simplified graph with a minimum of 2 quotes.

Source: Authors.

The species popularly named boldo are among the most cited in ethnobotanical studies in Brazil (GOIS *et al*., 2016). Borges and Moreira (2016) surveyed medicinal species used by family members of students attending courses at the Federal Institute of Mato Grosso Campus Confresa, where boldo (*Plectranthus barbatus* Andr.) obtained 10.6%, lemongrass (*Cymbopogon citratus* (DC.) Stapf) 9.5% and *Aloe vera* (L.) Burn f) 7.7% of citations.

Through the order of citation of each informant, the Salience Index (IS) was calculated for the plants of greatest cultural importance, namely: boldo (IS = 0.649), followed by lemongrass (IS = 0.435) and lemon balm (IS = 0.360). With this, it is possible to demonstrate the importance of local knowledge of the species popularly known as boldo, lemongrass, and lemon balm (Table 3), which are precisely the same species that had the highest number of citations.

Tabela 3 | Relação das espécies classificadas pelo IS, obtida por meio das citações feitas pelos informantes do Ciampa.

ESPÉCIE	*IS*	*ESPÉCIE*	*IS*
Boldo	0,649	Marissol	0,061
Capim-limão	0,435	Carqueja	0,061
Erva-cidreira	0,360	Sabugueiro	0,059
Saião	0,214	Erva-doce	0,059
Cana-do-brejo	0,196	Canela	0,057
Arnica	0,193	Aveloz	0,053
Quebra-pedra	0,177	Poejo	0,053
Guaco	0,177	Coloral	0,051
Embaúba	0,171	Hamamelis virginiana	0,051
Babosa	0,152	Beterraba	0,045
Macaé	0,140	Gengibre	0,045
Camomila	0,135	Pitanga	0,043
Graviola	0,130	Arruda	0,040
Hortelã	0,130	Melancia	0,040
Pau-d'alho	0,128	Picão	0,034
Mertiolate	0,127	Rosa-branca	0,032
Erva-de-santa-maria	0,119	Alecrim-do-campo	0,032
Romã	0,108	Agrião	0,030
Hortelã-pimenta	0,099	Limoeiro	0,030
Boldo-do-chile	0,091	Jojoba	0,030
Pinhão-roxo	0,091	Rosa-mosqueta	0,020
Jaborandi	0,091	Dormideira	0,020
Penicilina	0,086	Aroeira	0,017
João-duro	0,086	Arnica-da-horta	0,016
Dente-de-leão	0,081	Abacate	0,015
Cordão-de-frade	0,080	Alho	0,015
Insulina	0,080	Joazeiro	0,013
Mamão-macho	0,071	Maracujá	0,011
Melão-de-são-caetano	0,064	Novalgina	0,010
Assa-peixe	0,062	Goiabeira	0,010
Parietária	0,061	Cravo-da-índia	0,006
Mangueira	0,061	Erva-de-bicho	0,005

Fonte: Elaboração própria.

Em um levantamento de plantas medicinais em quatro bairros do município de Resende, no estado do Rio de Janeiro, observou-se que o boldo ficou entre as dez espécies mais importantes culturalmente (BALDINI, 2015).

É notável a importância das espécies nomeadas como boldo em levantamentos etnobotânicos no Brasil (GOIS *et al.*, 2016), tanto em comunidades urbanas quanto em comunidades periurbanas. Torna-se necessário o conhecimento das espécies que possuem o mesmo nome popular, como também o profundo conhecimento de seus efeitos medicinais e adversos.

3.3 LISTA DAS ESPÉCIES MEDICINAIS SELECIONADAS

O levantamento feito por meio de documentos disponibilizados pelo governo federal resultou em 174 espécies medicinais, enquanto a relação de plantas levantadas por meio dos informantes do Ciampa, após aplicação da metodologia "pistas taxonômicas", resultou em 85 espécies. Depois do processamento e da união de ambas as listas, foi possível obter o quantitativo de 209 espécies, das quais 66 são nativas (Tabela 4). Essa lista será utilizada para elaboração do cultivo, seguindo as normais da tecnologia social Pais. O corpo técnico do CRS/JBRJ, porém, fará uma triagem para escolher as espécies que melhor se adaptam à região de Campo Grande.

Tabela 4 | Listagem das espécies medicinais citadas pelos informantes do Ciampa correlacionadas aos documentos disponibilizados pelo governo federal.

Nº	*Nome Científico*	*Nome Popular*	*Cit*	*Na*	*Ex*	*Nat*	*Cul*	*FB*	*FFFB*	*MFFB*	*RENAME*	*RENISUS*
1	*Absinthium vulgare* Lam. = *Artemisia absinthium* L.	Losna					X					X
2	*Achillea millefolium* L.	Mil-folhas	X			X			X			X
3	*Achyrocline satureioides* (Lam.) DC.	Macela		X				X	X			
4	*Aconitum napellus* L.	Acônito			X			X				
5	*Actaea racemosa* L.	Erva-de-são--cristóvão			X				X	X		
6	*Aesculus hippocastanum* L.	Castanheiro--da-índia					X	X	X	X		
7	*Allium sativum* L.	Alho	X				X	X	X	X		X
8	*Aloe africana* Mill.	Babosa	X				X	X				
9	*Aloe ferox* Mill.	Babosa	X				X	X				
10	*Aloe spicata* L. f	Babosa	X				X	X				
11	*Aloe vera* (L.) Burm. f.	Babosa	X				X	X		X	X	X
12	*Aloysia polystachya* (Griseb.) Moldenke	Burrito			X				X			
13	*Alpinia zerumbet* (Pers.) B.L. Burtt & R.M. Sm	Colônia					X		X			X
14	*Alternanthera brasiliana* (L.) Kuntze	Penicilina	X	X								
15	*Althaea officinalis* L.	Malva-branca			X			X				
16	*Anacardium occidentale* L.	Cajueiro		X								X
17	*Anadenanthera colubrina* (Vell.) Brenan	Angico-branco		X				X				
18	*Ananas comosus* (L.) Merril	Abacaxi		X								X
19	*Anethum graveolens* L.	Endro				X		X				
20	*Annona muricata* L.	Graviola	X				X					

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
21	*Arctium lappa* L.	Bardana				X			X			
22	*Arctostaphylos uva-ursi* (L.) Spreng.	Uva-ursi			X			X				
23	*Arnica montana* L.	Arnica	X		X			X				
24	*Atropa belladonna* L.	Beladona			X			X				
25	*Attalea speciosa Mart. ex Spreng. = Orbignya speciosa* (Mart.) Barb. Rodr.	Babaçu		X								X
26	*Baccharis articulata* (Lam.) Pers.	Carqueja-doce	X	X								
27	*Baccharis dracunculifolia* DC.	Alecrim-do--campo	X	X								
28	*Baccharis trimera* (Less.) DC.	Carqueja	X	X				X	X			X
29	*Bauhinia affinis* Vogel	Pata-de-vaca		X								X
30	*Bauhinia forficata* Link	Pata-de-vaca		X								X
31	*Bauhinia variegata* L.	Pata-de-vaca					X					X
32	*Beta vulgaris* L.	Beterraba	X				X					
33	*Bidens alba* (L.) DC.	Picão-branco	X	X								
34	*Bidens pilosa* L.	Picão-preto				X						X
35	*Bixa orellana* L.	Urucum	X	X								
36	*Bryophyllum pinnatum* (Lam.) Kurz	Folha-da-fortuna	X		X							
37	*Buxus chinensis* Link = *Simmondsia chinensis* (Link) C.K. Schneid.	Jojoba	X		X							
38	*Calendula officinalis* L.	Calêndula					X	X	X	X		X
39	*Carapa guianensis* Aubl.	Andiroba		X								X
40	*Carica papaya* L.	Mamoeiro	X			X						
41	*Casearia sylvestris* Sw.	Guaçatonga		X								X
42	*Cecropia ficifolia* Warb. ex Snethl.	Embaúba	X	X								
43	*Centella asiatica* (L.) Urb.	Centelha-asiá-tica				X		X				
44	*Cinchona calisaya* Wedd.	Quina			X			X				
45	*Cinnamomum cassia* (L.) J. Presl	Canela-da--china	X				X	X				
46	*Cinnamomum verum* J. Presl	Canela	X		X			X				

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
47	*Cissus sicyoides* L. = *Cissus verticillata* (L.) Nicolson & C.E.Jarvis	Insulina-vegetal	X	X								
48	Citrullus lanatus *(Thunb.) Matsum. & Nakai*	Melancia	X				X					
49	*Citrus ×limon* (L.) Osbeck	Limão	X			X		X				
50	*Citrus aurantium* L. subsp. Aurantium	Laranjeira-azeda					X	X				
51	*Citrus sinensis* (L.) Osbeck	Laranjeira-doce					X	X				
52	*Cola nitida* (Vent.) Schott & Endl.	Noz-de-cola			X			X				
53	*Copernicia prunifera* (Mill.) H.E. Moore	Carnaúba		X				X				
54	*Coriandrum sativum* L.	Coentro				X		X				
55	*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson	Eucalipto-limão					X	X				
56	*Costus scaber* Ruiz & Pav.	Cana-do-brejo	X	X								X
57	*Costus spicatus* (Jacq.) Sw.	Cana-do-brejo	X		X							X
58	*Crataegus azarolus* L.	Crataegus			X			X	X			
59	*Crataegus laevigata* (Poir.) DC.	Pilriteiro			X			X	X			
60	*Crataegus monogyna* Jacq.	Pilriteiro			X			X	X			
61	*Crataegus nigra* Waldst. & Kit.	Espinheiro-húngaro			X			X	X			
62	*Crataegus pentagyna* Waldst. & Kit. ex Willd.	Espinheiro-preto			X			X	X			
63	*Crataegus rhipidophylla* Gand.	Espinheiro-alvar			X			X	X			
64	*Croton cajucara* Benth.	Marassacaca		X								X
65	*Croton grewioides* Baill. = *Croton zehntneri* Pax & K. Hoffm.	Alecrim-de-cabloca		X								X
66	*Curcuma longa* L.	Açafrão-da-terra					X	X	X			X
67	*Cymbopogon citratus* (DC.) Stapf	Capim-limão	X			X		X				
68	*Cymbopogon martini* (Roxb.) W. Watson	Palmarosa	X				X	X				
69	*Cynara scolymus* L.	Alcachofra			X			X	X	X	X	X
70	*Dalbergia subcymosa* Ducke	Verônica		X								X
71	*Datura stramonium* L.	Castanheiro-do-diabo				X		X				

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
72	*Dysphania ambrosioides* (L.) Mosyakin & Clemants = *Chenopodium ambrosioides* L.	Erva-de-santa-maria	X			X						X
73	*Echinacea angustifolia* DC.	Equinácea			X				X			
74	*Echinacea purpurea* (L.) Moench	Equinácea			X				X	X		
75	*Echinodorus grandiflorus* (Cham. & Schltdl.) Micheli	Chapéu-de--couro		X				X				
76	*Elettaria cardamomum* (L.) Maton	Cardamomo			X			X				
77	*Equisetum arvense* L.	Cavalinha			X				X	X		
78	*Eucalyptus globulus* Labill.	Eucalipto					X	X	X			
79	*Eugenia uniflora* L.	Pitangueira	X	X				X				
80	*Euphorbia prostrata* Ailton.	Quebra-pedra--rasteiro	X	X								
81	*Euphorbia tirucalli* L.	Quebra-pedra	X				X					
82	*Foeniculum vulgare* Mill.	Funcho	X			X		X	X			
83	*Frangula purshiana* (DC.) A. Gray	Cáscara-sagrada			X			X	X			
84	*Fridericia chica* (Bonpl.) L.G. Lohmann = *Arrabidaea chica* (Bonpl.) Verl.	Crajiru		X								X
85	*Gallesia integrifolia* (Spreng.) Harms	Pau-d'alho	X	X								
86	*Gentiana lutea* L.	Genciana-amarela			X			X				
87	*Ginkgo biloba* L.	Ginkgo-biloba					X			X		
88	*Glycine max* (L.) Merr.	Soja					X		X	X	X	
89	*Glycyrrhiza glabra* L.	Alcaçuz			X			X	X			
90	*Glycyrrhiza inflata* Batalin	Alcaçuz			X				X			
91	*Glycyrrhiza uralensis* Fisch.	Alcaçuz			X				X			
92	*Gossypium hirsutum* L.	Algodoeiro				X		X				
93	*Gymnanthemum amygdalinum* (Delile) Sch.Bip. ex Walp.	Boldo	X			X						X
94	*Hamamelis virginiana* L.	Hamamélis	X		X			X				
95	*Handroanthus impetiginosus* (Mart. ex DC.) Mattos = *Tabebuia avellanedae* Lorentz ex Griseb.	Ipê-roxo		X					X			X

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
96	*Harpagophytum procumbens* DC. ex Meissn.	Garra-do-diabo			X			X	X	X	X	
97	*Harpagophytum zeyheri* Decne	Garra-do-diabo			X			X	X	X		
98	*Helianthus annuus* L.	Girassol					X	X				
99	*Hydrastis canadensis* L.	Hidraste			X			X				
100	*Hyoscyamus niger* L.	Meimendro--negro			X			X				
101	*Hypericum perforatum* L.	Erva-de-são--joão			X				X	X		
102	*Illicium verum* Hook. f.	Anis-estrelado					X	X				
103	*Jatropha gossypiifolia* L.	Pinhão-roxo	X	X								
104	*Jatropha multifida* L.	Flor-de-coral	X				X					
105	*Justicia pectoralis* Jacq.	Chambá		X				X				
106	*Kalanchoe brasiliensis* Cambess.	Saião	X	X								
107	*Krameria lappacea* (Dombey) Burdet & B.B. Simpson	Ratânia-peruana			X			X				
108	*Lavandula angustifolia* Mill.	Alfazema					X	X				
109	*Leonotis nepetifolia* (R.Br.) W.T. Aiton	Cordão-de--frade	X			X						
110	*Leonurus cardiaca* L.	Agripalma			X			X				
111	*Leonurus japonicus* Houtt.	Rubim	X			X						
112	*Libidibia ferrea* (Mart. ex Tul.) L.P. Queiroz = *Caesalpinia ferrea* Mart. ex Tul.	Pau-ferro		X								X
113	*Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson	Cidreira	X	X				X				
114	*Lippia sidoides* Cham. = *Lippia origanoides* Kunth	Alecrim-pimenta		X				X		X		X
115	*Malva sylvestris* L.	Malva			X							X
116	*Mangifera indica* L.	Mangueira	X				X					
117	*Matricaria chamomilla* L.	Camomila	X				X			X		X
118	*Maytenus aquifolia* Mart. = *Monteverdia aquifolia* (Mart.) Biral	Espinheira--santa		X						X		X
119	*Maytenus ilicifolia* Mart. ex Reissek = *Monteverdia ilicifolia* (Mart. Ex Reissek) Biral	Espinheira--santa		X				X		X	X	X
120	*Melaleuca alternifolia* (Maiden & Betche) Cheel	Árvore-do-chá					X	X				

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
121	*Melissa officinalis* L.	Erva-cidreira	X				X	X				
122	*Mentha arvensis* L.	Hortelã-japonesa					X	X				
123	*Mentha crispa* L.	Menta	X			X						X
124	*Mentha pulegium* L.	Poejo	X			X						X
125	*Mentha villosa* Huds.	Hortelã	X		X							X
126	*Mentha x piperita* L.	Menta-piperita	X				X	X			X	X
127	*Mikania glomerata* Spreng.	Guaco	X	X				X			X	X
128	*Mikania laevigata* Sch.Bip. ex Baker	Guaco	X	X				X			X	X
129	*Mimosa pudica* L.	Dormideira	X	X								
130	*Momordica charantia* L.	Melão-são-caetano	X			X						X
131	*Myristica fragrans* Houtt.	Moscadeira			X			X				
132	*Myroxylon balsamum* (L.) Harms var. balsamum	Bálsamo-de-tolu		X				X				
133	*Myroxylon balsamum* (L.) Harms var. pereirae (Royle) Harms	Bálsamo-do--peru		X				X				
134	*Nasturtium officinale* W.T. Aiton = *Rorippa nasturtium-aquaticum* (L.) Hayek	Agrião	X				X					
135	*Ocimum gratissimum* L.	Alfavacão				X						X
136	*Olea europaea* L.	Oliveira					X	X				
137	*Operculina macrocarpa* (L.) Urb.	Batata-de-purga		X				X				
138	*Parietaria officinalis* L.	Parietária	X				X					
139	*Passiflora alata* Curtis	Maracujá	X	X				X				X
140	*Passiflora edulis* Sims	Maracujá-doce	X	X				X				X
141	*Passiflora incarnata* L.	Maracujá	X				X	X		X		X
142	*Paullinia cupana* Kunth	Guaraná		X						X		
143	*Pectis brevipedunculata* (Gardner) Sch. Bip.	Capim-limão--de-flor	X	X								
144	*Persea americana* Mill.	Abacateiro	X			X						X
145	*Petroselinum sativum* Hoffm.	Salsa					X					X
146	*Peumus boldus* Molina	Boldo-do-chile	X		X					X		
147	*Phyllanthus niruri* L.	Quebra-pedra	X	X				X				X
148	*Phyllanthus tenellus* Roxb.	Quebra-pedra	X	X								X

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
149	*Phyllanthus urinaria* L.	Quebra-pedra	X	X								X
150	*Pilocarpus microphyllus* Stapf ex Wardlew.	Jaborandi	X	X								
151	*Pimpinella anisum* L.	Erva-doce	X				X					
152	*Piper anisum* (Spreng.) Angely	Jaborandi	X	X								
153	*Piper methysticum* G. Forst	Kava-kava					X			X		
154	*Plantago major* L.	Transagem				X		X				X
155	*Plantago ovata* Forssk.	Transagem			X						X	
156	*Plectranthus amboinicus* (Lour.) Spreng.	Hortelã-grossa	X				X					
157	*Plectranthus barbatus* Andrews	Boldo-de-jardim	X				X	X				X
158	*Polygala senega* L.	Polígala			X			X				
159	*Polygonum hydropiperoides* Michx.	Erva-de-bicho	X	X								X
160	*Polygonum punctatum* Elliott = *Polygonum acre* Kunth	Erva-de-bicho		X								X
161	*Portulaca pilosa* L.	Amor-crescido		X								X
162	*Prunus domestica* L.	Ameixeira-europeia					X	X				
163	*Psidium guajava* L.	Goiabeira	X			X				X		X
164	*Punica granatum* L.	Romã	X			X		X				X
165	*Quillaja saponaria* Molina	Quilaia			X			X				
166	*Rauwolfia serpentina* (L.) Benth. ex Kurz	Rauwolfia-serpentina			X			X				
167	*Rhamnus purshiana* DC.	Cáscara-sagrada			X					X	X	X
168	*Rheum officinale* Baill.	Ruibarbo-chinês			X			X				
169	*Rheum palmatum* L.	Ruibarbo			X			X				
170	*Rosa alba* L.	Rosa-branca	X				X					
171	*Rosa rubiginosa* L.	Rosa-mosqueta	X				X					
172	*Ruta graveolens* L.	Arruda	X		X							X
173	*Salix alba* L.	Salgueiro-branco					X				X	X
174	*Salix daphnoides* Vill.	Salgueiro-violeta			X			X				
175	*Salix fragilis* L.	Salgueiro-frágil			X			X				

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
176	*Salix purpurea* L.	Salgueiro-de--casca-roxa			X			X				
177	*Salvia officinalis* L.	Sálvia					X	X				
178	*Salvia rosmarinus* Schleid. = *Rosmarinus officinalis* L.	Alecrim					X	X				
179	*Sambucus australis* Cham. & Schltdl.	Sabugueiro	X	X								
180	*Sambucus nigra* L.	Sabugueiro	X			X		X				
181	*Schinus terebinthifolia* Raddi	Aroeira	X	X							X	X
182	*Senna alexandrina* Mill.	Sene				X				X		
183	*Serenoa repens* (W. Bartram) Small	Saw-palmetto			X			X		X		
184	*Silybum marianum* (L.) Gaertn.	Cardo-mariano				X		X				
185	*Solanum paniculatum* L.	Jurubeba		X								X
186	*Solidago chilensis* Meyen = *Solidago microglossa* DC.	Arnica-brasi-leira	X	X								X
187	*Stevia rebaudiana* (Bertoni) Bertoni	Estévia		X				X				
188	*Strychnos nux-vomica* L.	Noz-vómica			X			X				
189	*Stryphnodendron adstringens* (Mart.) Coville	Barbatimão		X						X		X
190	*Styrax benzoin* Dryand.	Benjoeiro			X			X				
191	*Syzygium aromaticum* (L.) Merr. & L.M. Perry	Cravo-da-índia	X				X					
192	*Syzygium cumini* (L.) Skeels	Jamelão				X						X
193	*Tagetes minuta* L.	Cravo-de-de-funto				X						X
194	*Tanacetum parthenium* (L.) Sch.Bip.	Tanaceto					X	X				
195	*Taraxacum officinale* F.H. Wigg.	Dente-de-leão	X			X		X				
196	*Theobroma cacao* L.	Cacau				X		X				
197	*Thymus vulgaris* L.	Tomilho					X	X				
198	*Trifolium pratense* L.	Trevo-dos-pra-dos				X		X		X		X
199	*Uncaria tomentosa* (Willd. ex Roem. & Schult.) DC.	Unha-de-gato		X				X		X	X	X
200	*Vaccinium macrocarpon* Aiton	Arando			X			X				
201	*Valeriana officinalis* L.	Valeriana					X	X		X		

Nº	Nome Científico	Nome Popular	Cit	Na	Ex	Nat	Cul	FB	FFFB	MFFB	RENAME	RENISUS
202	*Vanilla planifolia* Jacks. ex Andrews	Baunilha		X				X				
203	*Varronia curassavica* Jacq. = *Cordia curassavica* (Jacq.) Roem. & Schult.	Erva-baleeira		X								X
204	*Vernonanthura polyanthes* (Sprengel) Vega & Dematteis	Assa-peixe	X	X								X
205	*Vernonanthura membranacea* (Gardner) H. Rob. = *Vernonia ruficoma* Gardner	Assa-peixe	X	X								X
206	*Vitex agnus-castus* L.	Vitex				X		X				
207	*Zea mays* L.	Milho					X	X				
208	*Zingiber officinale* Roscoe	Gengibre	X				X	X		X		X
209	*Ziziphus joazeiro* Mart.	Joazeiro	X	X								

Fontes Pesquisadas: FB: Farmacopeia Brasileira (6ª edição); **FFFB:** Formulário de Fitoterápicos da Farmacopeia Brasileira (1º edição - Primeiro Suplemento); **MFFB:** Memento Fitoterápico da Farmacopeia Brasileira; **Rename:** Relação Nacional de Medicamentos Essenciais; **Renisus:** Relação Nacional de Plantas Medicinais de Interesse ao Sistema Único de Saúde (SUS).

Legenda: Cit: *Espécies medicinais que possuem nome popular idêntico às citadas pelos informantes;* **Na:** *Espécie nativa;* **Ex:** *Espécie exótica;* **Nat:** *Espécie naturalizada;* **Cul:** *Espécie cultivada.*

A Política Nacional de Plantas Medicinais e Fitoterápicos (PNPMF) aconselha a intensificação de pesquisas e desenvolvimento de novas tecnologias em plantas medicinais nativas e exóticas adaptadas da flora brasileira, utilizando-as de forma sustentável (BRASIL, 2016).

Dentro desse contexto, a diretriz 5 prioriza as necessidades epidemiológicas da população, enquanto a subdiretriz 7.3 incentiva pesquisas para ampliação do número de espécies nativas da flora brasileira na farmacopeia brasileira (BRASIL, 2016).

As espécies vegetais elencadas acima (Tabela 4) se encaixam nos perfis de biodiversidade que a PNPMF sugere para o desenvolvimento de pesquisas, bem como para o uso racional de espécies já estudadas.

A listagem geral atende ao objetivo desenvolvido pelo corpo técnico do CRS/JBRJ, que é a utilização de espécies vegetais com propriedades medicinais em um espaço que agregue formação de recursos humanos e permeação de valores socioculturais às necessidades terapêuticas contemporâneas. Cada espécie tem uma história e isso poderá ser trabalhado durante e após a implantação da tecnologia social Pais.

A Política Nacional de Práticas Integrativas e Complementares (PNPIC) possui perspectivas semelhantes à PNPMF, isso pode ser observado por meio da diretriz PMF7 (Plantas Medicinais e Fitoterapia), porque fala sobre o incentivo de pesquisas e desenvolvimentos tecnológicos baseados no uso tradicional das espécies medicinais, com prioridade para as necessidades epidemiológicas da população com ênfase nas espécies nativas (BRASIL, 2015).

A listagem geral apresentada na Tabela 4 vai ao encontro das duas políticas públicas, PNPMF e PNPIC, porque grande parte das espécies medicinais listadas é nativa e exótica cultivada no território brasileiro. Além disso, houve a participação da população local que indicou espécies nativas com usos tradicionais, como *A. brasiliana*, *B. dracunculifolia*, *B. trimera*, *B. alba*, *B. orellana*, *C. ficifolia*, *E. uniflora*, entre outras.

É importante ressaltar a relevância dos preceitos da tecnologia social Pais, a qual segue um padrão de cultivo agroecológico capaz de agrupar diferentes espécies em um único local. Portanto, torna-se ideal para implantação no setor socioambiental do Ciampa, já que o local tem espaço para receber um quantitativo grande de espécies vegetais.

A visão e a missão do setor socioambiental do Ciampa são compatíveis com os objetivos da sustentabilidade por meio das atividades de reflorestamento executadas nos locais degradados do entorno. E a estruturação desse cultivo gera oportunidade inédita de desenvolvimento de atividades de ensino e pesquisa na área agroecológica com plantas medicinais.

3.4 ADAPTAÇÃO DA METODOLOGIA *SWOT-AHP*

A metodologia *Swot-AHP* adaptada a este trabalho identificou as potencialidades e fragilidades do sistema estratégico e operacional do setor socioambiental de maneira integrada (FORMIGA JR.; CÂNDIDO; AMARAL, 2015) e foi capaz de originar novos caminhos metodológicos.

A Figura 4 apresenta as estratégias de gestão utilizadas para estruturação e compilação de espécies medicinais com importância cultural, somadas a espécies medicinais que possuem importância nacional para o Ministério da Saúde (MS).

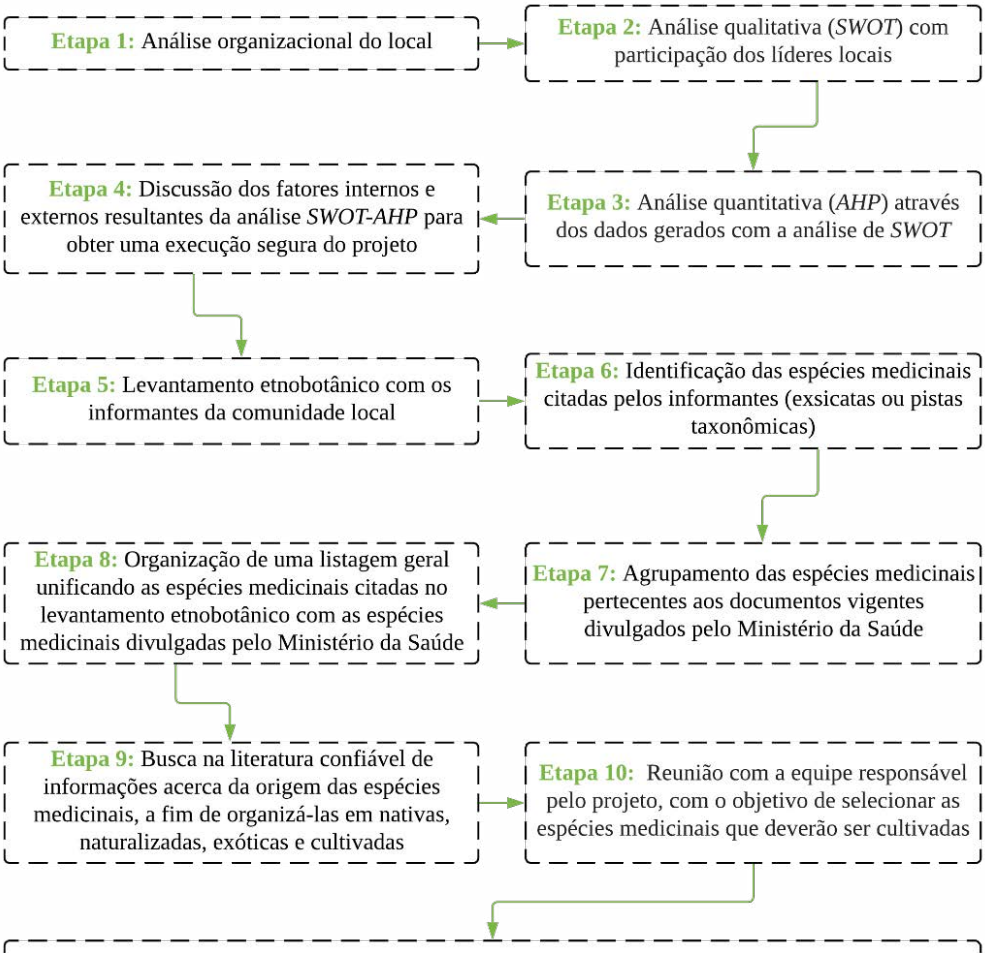

Figura 4 | Etapas metodológicas com enfoque na estruturação e compilação de espécies medicinais para implantação de uma tecnologia social envolvendo o cultivo.

Fonte: Elaboração própria.

4 CONSIDERAÇÕES FINAIS

O método *Swot-AHP* foi peça-chave para o desenvolvimento das atividades do setor socioambiental do Ciampa, além de organizar os caminhos necessários para a implantação de um cultivo sustentável baseado na tecnologia Pais.

A presente metodologia é aplicável na área ambiental e deve fazer parte da gestão do setor socioambiental, de forma a desenvolver as atividades necessárias para o crescimento do setor e principalmente o desenvolvimento da tecnologia social Pais com plantas medicinais.

Um dos fatores principais esclarecidos até aqui diz respeito à identificação de pontos estratégicos e fundamentais para a necessidade de implantar uma equipe de captação de recursos e outra para implantação de projetos, merecendo destaque a seleção de espécies medicinais de interesse público nacional, levando-se em conta o conhecimento tradicional local, para compor a futura estrutura feita com tecnologia social Pais.

O passo seguinte a ser dado é a escolha das espécies por meio da listagem geral, com o propósito de construir o desenho dos canteiros da mandala baseado nas particularidades de cultivo de cada espécie. Dentro desse contexto, a ideia é que as espécies sejam agrupadas por biomas para serem desenvolvidas atividades didáticas sobre a biodiversidade brasileira nativa e exótica naturalizada e cultivada.

A implantação de um cultivo agroecológico no setor socioambiental do Ciampa depende da realização do curso de jardinagem, do apoio voluntário da comunidade local proposto pelo coordenador e o apoio técnico do CRS/JBRJ. São grandes oportunidades que devem ser trabalhadas no início da implantação do cultivo, bem como para a continuidade das atividades no setor.

Graças à adaptação do método *Swot-AHP* ao presente trabalho, foi possível organizar caminhos fundamentais para o desenvolvimento de trabalhos na área de sustentabilidade que tenham como propósito organizar ou montar um setor ambiental baseado no cultivo de plantas medicinais.

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Complex innovations in agriculture, environment, and health – the perceptions of rice farmers in the Jequetepeque Valley, Peru

Inovações complexas em agricultura, meio ambiente e saúde – as percepções de produtores de arroz do Vale do Jequetepeque, Peru

Renata Távora [1]
José Augusto Drummond [2]
Alain Santandreu [3]
Anita Luján [4]
Ernesto Ráez-Luna [5]
Ester Montalvan [6]
Elena Ogusuko [7]
Frédéric Mertens [8]

[1] *PhD in Sustainable Development, Researcher, INCT-ODISSEIA, Universidade de Brasília, Brasília, Brazil*
E-mail: renata.tavora@gmail.com

[2] *PhD in Land Resources, Professor, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília, Brazil*
E-mail: jaldrummond@uol.com.br

[3] *Graduate in Sociology, Executive Director, Consorcio por la Salud, Ambiente y Desarrollo (Ecosad), Lima, Peru*
E-mail: alain.santandreu@gmail.com

[4] *Graduate in Nursing, Professor, Universidad Nacional Mayor de San Marcos, Lima, Peru*
E-mail: alujang@unmsm.edu.pe

[5] *Master in Latin American Studies, Executive Director, Instituto del Bien Común, Lima, Peru*
E-mail: eraez@ibcperu.org

[6] *Bachelor of Social Sciences, Social Facilitator, Inerco, Piura, Ayabaca, Peru*
E-mail: montalvan.ts@hotmail.com

[7] *Bachelor in Biology, Dirección General de Salud Ambiental e Inocuidad Alimentaria, Ministerio de Salud, Lima, Peru*
E-mail: elenaoa2013@gmail.com

[8] *PhD in Environmental Sciences, Professor, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília, DF, Brazil*
E-mail: mertens.br@gmail.com

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ABSTRACT

The increased use of water in irrigated rice monocultures in the Jequetepeque Valley, on the northern coast of Peru, has exacerbated environmental, socioeconomic and health problems. The Alternate Wetting and Drying (AWD) irrigation technique aims to increase water management efficiency in rice cultivation. The objective of the present article is to understand farmers' perceptions about the benefits and risks of implementing AWD. Data from interviews with 319 farmers showed that they recognise nine interactions between AWD's economic, environmental and health aspects but prioritise economic factors when assessing its benefits. We also identified the main channels and spaces of communication and debate on issues related to agriculture and health that are likely to be effective in promoting the diffusion of AWD. The study demonstrated the relevance of integrated actions to encourage the adoption of agricultural innovations which consider the interactions between environmental sustainability, health issues, and producers' economic priorities.

Keywords: Diffusion of innovations. Agriculture. Rice. Intermittent irrigation. Malaria. Sustainability.

RESUMO

O aumento do uso de água nas monoculturas de arroz irrigado do Vale do Jequetepeque (costa norte do Peru) vem agravando problemas ambientais, socioeconômicos e de saúde. Nesse contexto, a Técnica de Irrigação com Secas Intermitentes (Tisi) oferece uma oportunidade de manejo mais eficiente da água no cultivo do arroz. O presente artigo buscou compreender as percepções dos agricultores sobre os benefícios e riscos do uso da Tisi. Dados de entrevistas com 319 agricultores mostraram que eles reconhecem as interações entre os aspectos econômicos, ambientais e de saúde, mas priorizam as questões econômicas para avaliar os benefícios da Tisi. Identificamos também os canais e espaços de comunicação privilegiados sobre os temas de agricultura e saúde com potencial de promover a difusão da Tisi. O estudo demonstrou a relevância de ações integradas para promover a adoção de inovações agrícolas, que considerem as interações entre sustentabilidade ambiental, questões de saúde e prioridades econômicas dos produtores.

Palavras-chave: Difusão de inovações. Agricultura. Arroz. Irrigação intermitente. Malária. Sustentabilidade.

1 INTRODUCTION

Water availability in the Jquetepeque Valley, located on the northern coast of Peru, has been gradually diminishing in the last decades. This is mainly due to a rice monoculture system with permanent irrigation, which is standard in the region. The entire northern coast is emblematic in its geo-climatic conditions and has been suffering for millennia with extreme and adverse events – sometimes prolonged droughts, sometimes exceptional rain – that produce generalised effects such as dune formation and desertification, as well as great floods along coastal rivers (GIRALT *et al*., 2007; RODRÍGUEZ-MORATA *et al*., 2019). Considering this scenario, agriculture is one of the productive activities that is most threatened by climate change, creating uncertainty and economic instability for the farmers in the region (PERU, 2016).

Permanent flood irrigation generates other problems contributing to farmers' vulnerability in the valley, such as increasing vector-borne diseases, including malaria (GUTHMANN *et al*., 2002). The condition is considered endemic in the region, and its control requires preventive measures, given the direct relation between irrigated agriculture and the proliferation of mosquito vectors (IBARGÜEN, 2019). In this sense, adopting more sustainable cultivation and irrigation practices may contribute to an agricultural production that is more efficient in economic terms, is less vulnerable to climate change, and presents fewer risks and damages to the environment and farmers' health families.

In 2014, the Peruvian Ministry of Health initiated a research and intervention to analyse the feasibility of the Alternate Wetting and Drying (AWD) irrigation technique to promote sustainability in rice production in the Jequetepeque valley. This practice was developed in Asia around 300 years ago. However, it is only in the last four decades that it has been systematised by international research groups and spread to other continents and countries, including Peru (KEISER; UTZINGER; SINGER, 2002; PERU, 2002). The technique consists of more efficient irrigation management in rice cultivation through controlled drought periods as a substitute for permanent flooding. AWD is considered a complex innovation because of its implications in many dimensions such as (i) socioeconomic, due to reduction in production cost; (ii) environmental, due to adequate water management and soil protection; and (iii) health, due to the reduction of habitat for the disease vector mosquitoes (PERU, 2012).

Rice farmers have not broadly adopted AWD on the northern Peruvian coast despite scientific evidence on socioeconomic, environmental, and health impacts. Understanding farmers' perceptions of the benefits and risks of implementing AWD is essential to addressing opportunities and challenges to its adoption on a large scale. This article aims to understand factors that can favour or hinder AWD implementation from the perception of rice farmers in the Jequetepeque valley on its socioeconomic, environmental, and health character following.

The following section presents a revision of scientific evidence on AWD benefits and limitations and factors frequently associated with perceptions of agricultural innovations.

1.1 ALTERNATE WETTING AND DRYING IRRIGATION TECHNIQUE (AWD)

In the last four decades, many research groups and international agencies have systematised alternative practices of rice cultivation that integrate the control of different irrigation regimes, also called *water-saving techniques* or *water-saving technology* (HUMPHREYS *et al.*, 2005). The practices seek to reduce water usage in irrigation and increase efficiency in its use without compromising productivity. One of these technologies is the Alternate Wetting and Drying irrigation technique (AWD), also known as intermittent irrigation.

A significant number of studies conducted in many countries has consolidated a robust knowledge on AWD, describing its many benefits and limitations (ENRIQUEZ *et al*., 2021). In Peru, studies performed since the 2000s have had an integrated focus on economic and health aspects, including the environmental dimension, as well as a solid participative content with strategies for political diffusion, communication, and regulation on rice cultivation in the country (CHÁVEZ, 2007; PERU, 2002, 2011, 2012; VÉLEZ, 2008). Hence, AWD can be characterised by its multidimensional properties that intervene simultaneously on socioeconomic, environmental, and health factors.

Previous research points to many socioeconomic benefits in implementing intermittent irrigation regimes in rice cultivation (ALEN; SANDER, 2019). In the northern coast of Peru, studies showed that AWD increased productivity per hectare by 20-25%, allowing less competition for resources between farmers (CHÁVEZ, 2007; PERU, 2002). Also, Awa D can reduce production costs, as it improves water usage efficiency and reduces expenses with irrigation, which are generally included in rice cultivation output calculation (ALAUDDIN *et al*., 2020). An AWD validation study in Peru in 2006, made by the Ministry of Health in a district close to the Jequetepeque valley, verified a 35% irrigation water saving per hectare (PERU, 2011).

On the other hand, the AWD application also presents some negative implications in the economic realm. One of them is the need to control weeds and other diseases that arise when there is no continuous irrigation (ISHFAQ *et al*., 2020). This generates an increase in labour costs to manage and remove these pests. However, some adjustments may bypass this problem, such as combining pre-emergent herbicides with shallow water for 10 to 15 days after transplant. This method may delay the crops' drying period, but helpful to control weeds as it increases herbicide efficacy and allows the plant to recover from transplantation shock (MUBEEN; JABRAN, 2019).

In the environmental dimension, research shows the significant contributions of AWD in diminishing the main environmental impacts related to rice cultivation. Permanently irrigated crops are an essential source of methane (CH_4), one of the leading gases of the Greenhouse Gas Effect (GGE), and contributes to 10% of global agricultural emission of CH_4 (ENRIQUEZ *et al*., 2021). Due to more rigorous control of volumes of water for irrigation, AWD can reduce CH_4 emissions by 48-93%. Other studies analysed the reduction of nitrous oxide (N_2O) emissions, another type of GGE emitted by rice crops, due to excessive nitrogen fertilisers (BALAINE *et al*., 2019). Also, AWD allowed for a natural correction of nutritional deficiencies in the soil with the increased microbial and macrofauna (worms and other invertebrates) that resurge in aerobic conditions, stimulating organic nutrient cycling (ALEN; SANDER, 2019).

The monitoring of irrigation regimes also reduces soil degradation produced by nutrient leaching and by salinisation. Traditional irrigation makes the salt found in the soil come to the surface, reducing crop productivity (GORDON; FINLAYSON; FALKENMARK, 2010). The application of AWD reduces saturation in these fields and soil fertility problems (HUMPHREYS *et al.*, 2005).

Rice monoculture is highly dependent on external input and agrochemicals, like chemical fertilisers, insecticides, fungicides, and herbicides, that provoke generalised contamination of ecosystems and increase health risks for workers (MACHER; LUNA, 2016). Many studies have described that AWD can reduce environmental contamination and human exposure because it adopts more selective criteria to use these products (ALEN; SANDER, 2019).

Regarding health, AWD has as its main benefit the reduction of vector-borne diseases, due to the elimination of habitat for mosquitoes that are vectors of malaria (*Anopheles albimanus*) and other diseases, as well as the *Aedes aegypti* (transmits dengue fever, yellow fever, chikungunya fever, and zika virus), and the *Culex* spp (vector to many viral encephalitis) (KEISER; UTZINGER; SINGER, 2002). Studies in the northern Peruvian coast showed that AWD considerably reduced (between 86 and 93%) the larvae of malaria-transmitting mosquito (CHÁVEZ, 2007; PERU, 2002, 2011, 2012).

Despite economic, environmental, and health benefits, successful implementation of AWD depends on other factors and local conditions, which interact with the innovation's characteristics and influence farmers' perspectives. Next, we will present many categories of relevant factors to understand farmers' perceptions of agricultural innovations.

1.2 FACTORS ASSOCIATED WITH PERCEPTION OF AGRICULTURAL INNOVATIONS

The process of adopting new ideas, practices, or behaviours in agricultural production is conditioned to a series of factors that can influence farmers' perception of the benefits and risks of these innovations (ROGERS, 2003). Three broad categories of factors are recognised as able to affect perceptions and the adoption of agricultural innovation (MEIJER *et al.*, 2015):

I. characteristics of farmers, that is, their socio-demographic profiles, their performances in collective spaces of political decisions and associativism, and knowledge and experience acquired in their productive contexts and about their environmental and health issues;

II. characteristics of the productive system, which includes information on the land, cultivation modes, and production costs; and

III. communication channels, formal and informal, which gather the many sources of information used by farmers on relevant themes for their agricultural production.

Next, we detail these three groups of factors, focusing on their relevance to farmers' perceptions of AWD in the Jequetepeque valley.

1.2.1 CHARACTERISTICS OF FARMERS

There is growing recognition of the importance of understanding gender roles in forming perceptions on complex innovations that involve multiple dimensions: socioeconomic, environmental, and health. Differences in interests, experiences, and culturally sanctioned functions to men and women in a given social context result in different decisions and behaviours on many themes (SAINT-CHARLES *et al.*, 2012). Men frequently ponder their decisions on the adoption of an innovation, preferably due to their economic benefits and contribution to family income (PHIRI *et al.*, 2004), while women's decisions are based on risk perception and vulnerabilities, leading to preventive behaviour in healthcare (MERTENS *et al.*, 2005, 2017) and adaptation to environmental and climate change (JIN; WANG; GAO, 2015).

Age, education, and experience in farming activity are widely recognised as human resource variables that can affect decisions in the adoption process (PROKOPY *et al.*, 2008). For example, an increase in age may negatively correlate with technological change; the older the farmers are, the less prone they are to an eventual risk, and the more they resist a new practice (KABII; HORWITZ, 2006). However, other authors showed that more experienced farmers tend to be more efficient in incorporating new technologies and have a higher chance of understanding the benefits of agricultural innovations (LEBLANC *et al.*, 2020). Additionally, farmers with higher educational levels tend to have a higher probability of adopting agricultural technologies that demand advanced technical abilities (BAUMGART-GETZ; PROKOPY; FLORESS, 2012).

Farmers' participation in associations, commissions, councils, and other decision-making spaces can make innovation more sustainable (BODIN; CRONA, 2008; OSTROM, 2000). The legitimacy of farmers' participation may favour more efficient planning and management of irrigation systems and increase farmers' perceptions of the benefits of innovations, as in the case of AWD (FULAZZAKY, 2017; PALIS *et al.*, 2017).

1.2.2 CHARACTERISTICS OF THE PRODUCTIVE SYSTEM

The size of the farm and its multi-functionality, that is, the diversification of income-generating activities beyond agriculture, such as materials provision, production services, or animal husbandry and commercialisation, may favour the perception of benefits and the adoption of agricultural innovations (CASWELL et al., 2001; MANSON et al., 2014). The availability of financing options also positively influences the adoption process because access to funds allows increased capacity to experiment with a new practice. Another important factor relates to production expenses since some methods demand less labour and input during production or are more water-efficient, reducing the total production cost (PROKOPY et al., 2008).

1.2.3 FORMAL AND INFORMAL COMMUNICATION CHANNELS

Rogers (2003) defines a communication channel as the means through which messages are transmitted from one individual to another. Channels can influence individual perception because they reduce uncertainty on a given innovation, favouring its adoption. Communication may follow formal channels through interpersonal relationships, such as mass media or informal channels (MERTENS *et al.*, 2017). Mass media includes radio, television, newspapers, and the internet, with the potential to reach a broad audience and spread relevant information for agricultural practices. Interpersonal communication relationships usually contribute to more than the dissemination of information since transmitted messages are discussed and interpreted according to the individual's social and cultural contexts (VALENTE; FOSADOS, 2006).

Interpersonal communication patterns are often different between men and women. Discussion of health issues and socio-environmental themes tend to form dissemination pathways that connect preferably people of the same gender (BURGOS; MERTENS, 2017; TRIANA *et al.*, 2016). However, relationships between men and women are essential for adopting sustainable practices that require collective implementation in homes or family groups (MERTENS; SAINT-CHARLES; MERGLER, 2012).

2 METHODOLOGY

2.1 MODEL OF ANALYSIS

Based on the revision of the main groups of factors presented above, Figure 1 illustrates the framework designed to analyse farmers' perception about AWD's multidimensional properties (economic, environmental, and health), as well as characteristics of farmers, of the productive system, and of communication channels, that can be associated with the perception of AWD benefits

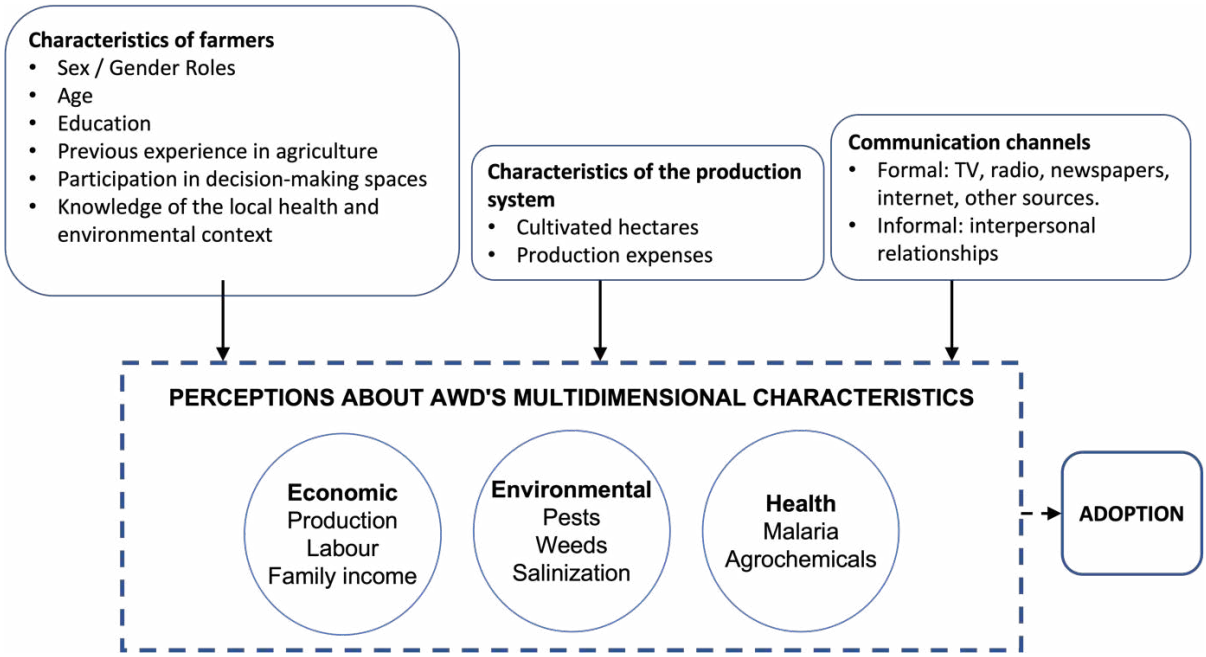

Figure 1 | Analytical framework designed to test associations between factors associated with farmers' perception of AWD.

Source: The authors.

2.2 AREA OF STUDY

The area studied is the Jequetepeque river basin, on the northern coast of Peru and approximately 645 km from the capital Lima. The crucialmost important rice production areas are located in the Jequetepeque Valley, in the lower part of the basin, from the Gallito Ciego Dam to the river mouth into the sea (Figure 2). The valley has an area of approximately 227,000 hectares (32.5% of the basin), of which 42,800 are arable. In 2017, the resident population was 181,315 inhabitants, living both in urban areas (91.7%) and in rural areas (8.3%) (INEI, 2018). This region is a hyper-arid zone characterised by low rainfall and high rates of evaporation. The climate is predominantly hot and dry, with an average annual rainfall of 150 mm and an average annual temperature of 24°C (PERU, 2016). Therefore, large-scale agriculture is highly dependent on irrigation infrastructure and proper management for water distribution and use.

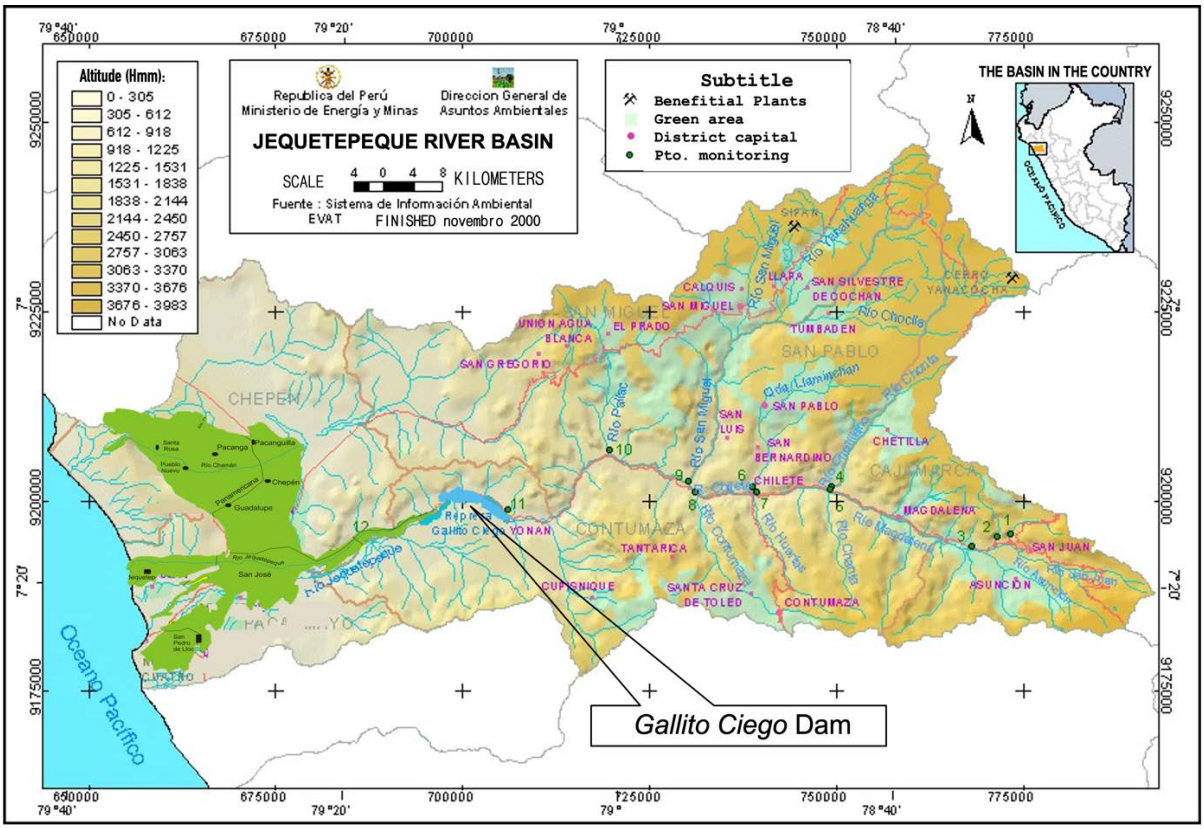

Figure 2 | Jequetepeque river basin highlights the Gallito Ciego dam and the Jequetepeque Valley (green area).

Source: (PERU, 2000) (adapted).

The valley's farmers are organised into different collective water management bodies. The main one is the *Junta de Usuarios del Agua del Valle del Jequetepeque* (JUAVJ), which brings together a total of 15,072 registered farmers. JUAVJ is a non-profit institution that operates and maintains the valley's hydraulic infrastructure. It manages water in a decentralised manner, through 14 Irrigation Commissions, responsible, in turn, for a series of hydraulic sectors, subdivided into Irrigation Committees, which organise the distribution of water to producer lots (GUERRERO-PADILLA, 2015; HUAMANCHUMO *et al*., 2008).

2.3 STUDY POPULATION

A sample for the study population was defined based on data provided by JUAVJ on the total number of farmers of legal age, registered as users of irrigation water and residing in the lower part of the Jequetepeque river basin (10,072 farmers). This calculation used the random sampling formula for proportions, considering a 95% confidence level and a 10% non-response rate. Thus, the approximate sample of the study population was 412 farmers. Then, a distribution, proportional to the strata size, that is, the population of each of the 14 Irrigation Commissions of Vale do Jequetepeque, was performed.

Within the ethical considerations of the project, a significant collective event was held with the participation of JUAVJ and its associated farmers. On that occasion, the different phases of the research were presented, including the experimental stages, where producers were informed about the benefits and possible difficulties of applying AWD and were able to use it to allocate parcels of their cultivation areas to the study. They were also informed about the stages of interviews, which the identified project team would conduct, considering voluntary participation, with prior informed consent from each producer and the anonymity of the information provided, to safeguard the safety and dignity of the participants.

Thus, during June and July 2014, semi-structured interviews were conducted to apply a questionnaire to a total of 372 farmers, of which 53 were discarded for containing incomplete data, resulting in a final sample of 319 farmers across the valley.

2.4 VARIABLES

Data were collected on the three groups of factors defined in the analytical framework (Figure 1):

I. Characteristics of agricultural producers: sociodemographic data (sex, age group, education, and years of experience in rice farming), participation in collective water management organisations (JUAVJ and Irrigation Committees) and knowledge about transmission aspects and prevention of malaria, differentiating between participants who are unaware of the subject, those who only know one part (transmission or prevention) and those who know both aspects;

II. Characteristics of the production system, including the size of the cultivated area (in hectares) and expenses with labour and purchase of inputs (fertilisers and pesticides). The data collected refer to the 2013-2014 harvest;

III. Communication channels used to obtain information on the themes of agriculture and health, namely: formal, referring to the use of mass media (television, radio, newspapers, and internet) and informal, referring to interpersonal communication networks, mapped from the identification of the people with whom the participants declared they had talked about each topic. Respondents were able to mention as many people as they wanted. Both discussion networks (on agriculture or health) were characterised according to their size (number of people the participant talked to), gender composition (number of women/men they spoke to) and family composition (number of people from the family or outside the family with whom he said). Individuals outside the family (non-relatives) could be neighbours, friends, co-workers, agricultural technicians, health professionals, among others.

2.5 THE MULTIDIMENSIONAL CHARACTERISTICS OF AWD AND THE CONSTRUCTION OF THE PERCEIVED BENEFITS INDEX

Participants' perception of the benefits and risks of adopting AWD was analysed using the question, "In your opinion, please indicate, among the options below, how AWD can affect the cultivation of rice on your property". A list of eight aspects was presented to the participant: (ec) economic, including rice production (ha), family income and employed labour; (en) environmental, referring to soil salinisation, the presence of pests and the appearance of weeds; and (h) health, referring to the occurrence of malaria and the use of pesticides. For each aspect, the participant indicated whether AWD could "benefit", "harm", "be indifferent", or "do not know how to give an opinion".

Individual responses were used to build a Perceived Benefits Index. For each aspect presented, the answers were scored as follows: zero, one or two points, when the participant identified, respectively, losses, lack of effect/could not give an opinion or benefits associated with the adoption of AWD. The points attributed to each characteristic were added up; the participants were divided into two groups, with predominantly negative (between 0-8 points) or positive (between 9-16 points) perceptions regarding the effects of adopting AWD.

2.6 STATISTICAL ANALYSIS

Descriptive statistical analyses include frequency distributions, means, and ranges. Data were disaggregated by sex to identify possible differences between men and women in the study population (Chi-square or t-Student tests). The Perception of Benefits Index was integrated into bivariate logistic regression models to verify possible associations between the factors of the three groups analysed and the perception of benefits on AWD (HOSMER; LEMESHOW, 2000).

3 RESULTS

3.1 THE FARMERS OF THE JEQUETEPEQUE VALLEY

Table 1 presents data on the characteristics of the study participants, which totalled 287 men and 32 women, and the productive system. The age of respondents ranged between 21 and 90 years old, with an elevated average age of 59. More than half of the participants (65.9%) have a level of education between primary and secondary, with an average of seven years of total duration informal studies. The time spent on rice farming is, on average, 26 years, with men having significantly more years of experience than women (p = 0.0004).

Regarding participation in collective water management entities, farmers participate, in more significant numbers, in local Irrigation Committees (56.4%), compared to the regional organisation of Vale do Jequetepeque (JUAVJ) (39.5%). Just over half of the study participants (50.8%) are aware of the transmission and prevention of malaria, with only 9% of women unaware of the subject, against 22% of men. Finally, 52% of participants have a predominantly positive perception of the effects of adopting AWD. There is no significant difference between the groups of men and women.

Participants cultivated an average of 4.4 hectares in the 2013/2014 harvest, with wide variation (1-43 hectares). Men cultivate, on average, land significantly more extensive than women (p = 0.0207). Most participants reported having expenses with the purchase of fertilisers (73%), pesticides (72.7%) or with the payment of labour (71.8%).

Table 1 | Frequency distribution of characteristics of farmers and production system, knowledge about malaria and perceptions of benefits of AWD for rice cultivation.

	Total (%)	*Men (%)*	*Women (%)*
Age			
21-30	2,8	2,8	3,1
31-40	7,2	7,7	3,1
41-50	15,7	14,6	25,0
51-60	27,0	26,1	34,4
61-70	26,6	28,9	6,3
71-80	16,6	15,7	25,0
81-90	4,1	4,2	3,1
Education (in years)			
Primary (0-5)	40,8	40,5	43,8
Secondary (6-10)	25,1	24,7	28,1
Undergraduate (11-15)	30,4	30,7	28,1
Graduate (16-18)	3,8	4,2	0

	Total (%)	Men (%)	Women (%)
Experience in farming (years)			
1-10	19,4	17,1	40,6
11-20	24,5	25,4	15,6
21-30	30,4	32,1	15,6
31-40	10,0	9,1	18,8
41-50	7,2	7,3	6,3
51-60	6,0	6,6	0,0
61-70	2,2	2,4	0,0
71-80	0,3	0,0	3,1
Participation in water management*			
JUAVJ	39,5	40,1	34,4
Irrigation Committees	56,4	57,1	50,0
Knowledge about malaria transmission and prevention			
Doesn't know	21,3	22,6	9,4
Knows one aspect	27,9	28,2	25,0
Knows both aspects	50,8	49,1	65,6
Perceived benefits of AWD			
Perceives little benefit	48,0	48,4	43,8
Perceives benefits	52,0	51,6	56,3
Total of cultivated hectares(ha)**			
Average / SD / Interval	4,4 / 5,2 / 0-43	4,6 / 5,4 / 0-43	2,4 / 1,6 / 0,5-5,5
Production costs			
Purchase of fertilisers	73,0	72,8	75,0
Purchase of pesticides	72,7	72,5	75,0
Labor	71,8	71,8	71,9

** Chi-Square (p = 0,0004); ** T-test (p = 0,0207)*
Source: Made by the authors (field research data).

Table 2(a) presents the frequencies of use, by the participants, of mass media to obtain information on themes related to agricultural activity and health. A little more than half of the participants use television (52.4%) and radio (50.8%) to obtain information about agriculture. Men use the radio at a significantly higher frequency (53%) than women (31.3%). Few respondents use newspapers (8.5%) and the Internet (3.1%). Other sources of information were indicated by 31% of the study participants, namely: information provided by the various irrigation commissions, materials distributed by other entities of the local government, JUAVJ, agro-industrial companies (Bayer, Farmex, Tecuse) and acquisition of farm inputs. About the topic of health, almost three quarters of the participants use television as their main source of information (71.5%). In second and third place are the radio (23.5%) and other sources of information (20.7%). The latter are offered during consultations at health clinics and centres, in pharmacies, in Municipal Health Social Insurance offices, in children's schools, by the Ministry of Health, in health magazines and books offered by doctors and in churches. The use of newspapers and the internet is less frequent: only 13.5% and 3.1% of participants consult them, the latter being used only by men.

Table 2 | Use of (a) formal and (b) informal communication channels to obtain information on agriculture and health.

(a) Formal channels			
	Total (%)	*Men (%)*	*Women (%)*
Agriculture			
TV	52,4	52,3	53,1
Radio*	50,8	53,0	31,3
Newspapers	8,5	8,7	6,3
Internet	3,1	3,5	0,0
Other sources	31,0	31,4	28,1
Health			
TV	71,5	70,4	81,3
Radio*	23,5	24,4	15,5
Newspapers	13,5	13,2	15,6
Internet	3,1	3,5	0,0
Other sources	20,7	20,6	21,9

(b) Informal channels							
	Total			*Men*		*Women*	
Interpersonal discussion on agriculture	***Average***	***SD***	***Interval***	***Average***	***SD***	***Average***	***SD***
Number of individuals	3,8	2,2	0-11	3,9	2,3	3,3	1,6
Number of men**	3,6	2,2	0-11	3,7	2,2	2,8	1,6
Number of women***	0,2	0,5	0-4	0,2	0,4	0,6	0,9
Number of relatives	0,5	0,8	0-4	0,4	0,8	0,6	0,8
Number of non-relatives	3,3	2,2	0-11	3,4	2,2	2,2	1,7
Interpersonal discussion on health	***Average***	***SD***	***Interval***	***Average***	***SD***	***Average***	***SD***
Number of individuals	2,4	1,5	0-6	2,4	1,6	2,2	0,9
Number of men	1,6	1,2	0-6	1,6	1,3	1,5	1,0
Number of women	0,8	0,9	0-4	0,8	0,9	0,7	0,7
Number of relatives	0,9	1,2	0-6	0,9	1,3	1,1	1,1
Number of non-relatives	1,4	1,3	0-6	1,5	1,4	1,1	0,2

*Chi-square (p<0,05); **Anova (p<0,05); *** Anova (p<0,0001)

Source: Made by the authors (field research data).

Table 2(b) presents the interpersonal communication data on agriculture and health between men and women participating in the study. The number of individuals with whom men and women talk about agriculture is similar, on average 3.9 people and 3.3 people, respectively. Both men and women converse, on average, with more men than women. However, men talk significantly more than women with other men, while women speak considerably more than men with other women. The discussion about agricultural practices occurs more frequently with people outside the family nucleus, on average 3.3 than with people from the same family, on average 0.5.

On average, men and women talk to similar people on health, and both preferentially speak to men about the subject. Men talk about the health issue preferably with individuals outside the family, while women talk in the same proportions with people outside the family and with family members.

3.2 FARMERS' PERCEPTION OF THE BENEFITS OF ADOPTING AWD FOR RICE CULTIVATION

Figure 3 shows the percentages of individuals who consider that AWD brings benefits, harms or is indifferent about economic (ec), environmental (en) and health (h) aspects of rice cultivation. The characteristic of AWD most often considered advantageous is related to reducing the occurrence of pests (65%). Second, many participants (59%) think it is positive that AWD allows for a reduction in the consumption of agrochemicals. The third most mentioned benefit (44%) concerns the increase in rice production. AWD aspects considered most harmful for rice cultivation are weed control (66%) and the need to employ more labour (37%). This is because periods of drought provide the appearance of opportunistic plants that compete with rice for soil nutrients, bringing losses to production and whose removal requires considerable labour for manual weeding. Many participants (63%) did not identify benefits or harms in the application of AWD about malaria incidence, probably because they were not aware that drought interrupts the larval cycle of mosquitoes that are vectors of the disease. The role of applying AWD to reduce soil salinisation was also not recognised by most participants.

Figure 3 | Percentages of participants who consider that AWD brings benefits, harms or is indifferent/does not know how to give an opinion regarding environmental (en), economic (ec) and health (h) aspects.

Source: Made by the authors (field research data).

3.3 FACTORS ASSOCIATED WITH PERCEIVED BENEFITS OF USING AWD FOR RICE CULTIVATION

Table 3 presents the results of the bivariate logistic regressions that show the probability of association between the characteristics of farmers and production systems, the channels of communication and the predominantly positive perception of the effects of AWD on rice cultivation. Previous experience in agriculture and participation in the two water management entities were associated with a greater likelihood of recognising benefits from AWD. Expenses with labour, the purchase of fertilisers and pesticides, and the level of knowledge about malaria transmission and prevention were also associated with a preferentially beneficial perception of AWD for rice cultivation. The other variables did not show a significant association.

Table 3 | Bivariate logistic regressions show the probability of association between the characteristics of the producers and the productive system, the communication channels, and the predominantly positive perception of AWD for rice cultivation.

Bivariate Models	*odd ratios*	*p*
Farmers' characteristics		
Sex	0,828	0,6154
Age	1,004	0,6342
Education	1,009	0,7246
Experience in agriculture	1,025	0,0150
Participation in JUAVJ	2,867	<0,0001
Participation in Irrigation Committees	2,457	0,0001
Knowledge about malaria	1,807	<0,0001
Productive systems' characteristics		
Total of cultivated hectares	0,974	0,2551
Purchase of fertilisers	2,444	0,0006
Purchase of pesticides	2,514	0,0004
Labour	2,393	0,0007
Formal communication channels on agriculture		
TV	0,956	0,8395
Radio	0,805	0,3352
Newspapers	0,608	0,2231
Internet	0,605	0,4432
Other sources	0,970	0,9003
Formal communication channels on health		
TV	1,229	0,4054
Radio	0,755	0,2878
Newspapers	2,698	0,0059
Internet	0,605	0,4432
Other sources	0,525	0,0221
Interpersonal discussion on agriculture		
Number of individuals	1,150	0,0082
Number of men	1,151	0,0087
Number of women	1,028	0,9007
Number of relatives	0,860	0,3065
Number of non-relatives	1,175	0,0032
Interpersonal discussion on health		
Number of individuals	1,088	0,2597
Number of men	1,059	0,5238
Number of women	1,141	0,3060
Number of relatives	0,813	0,0253
Number of non-relatives	1,355	0,0008

Source: Made by the authors (field research data).

None of the formal means of communication used to obtain information about agriculture was associated with participants' perception of the benefits or harms of adopting AWD. The use of newspapers and other sources of data on the topic of health, on the other hand, was significantly associated with the perception of benefits in using the practice. The number of individuals, men, and people outside the family with whom the participants discussed agriculture was positively associated with the perception of the benefits of AWD. The greater the number of members outside the family with whom one talks about health, the greater the probability that the farmer will consider that AWD has advantages for rice cultivation. On the contrary, participants who speak to family members about health are less likely to think that the use of AWD is preferentially beneficial for rice cultivation.

4 DISCUSSION

This article demonstrates that producers recognise the interactions between AWD's economic, environmental and health aspects but consider the financial aspects of the production process primarily when evaluating the benefits and losses potentially brought by the adoption of the technique. Among the characteristics of AWD considered the most beneficial (pest control, reduction of agrochemicals, productivity, and family income), the first two have implications for environmental aspects, improving pest control and human health through more effective management of agrochemicals. The last two most beneficial characteristics address essentially economic elements, such as increased production and family income. However, the economic benefits of AWD gain relevance as both the occurrence of pests and the use of agrochemicals interfere with production costs. Similarly, producers who declared they had expenses to purchase fertilisers, pesticides, and hiring labour also considered AWD predominantly brings advantages. Primarily among these producers, it is likely that the implementation of the practice, which reduces production expenses, is readily perceived as advantageous, as pointed out in previous studies (MUBEEN; JABRAN, 2019).

The two aspects of AWD considered most harmful to rice production also have economic implications for the producer. Crop field irrigation directly controls weeds in rice fields, which proliferate without the permanent layer of water (ISHFAQ *et al*., 2020). Thus, the change from the water-intensive regime to more aerobic cultivation may mean an increase in production costs, through the purchase and application of herbicides, but mainly through the hiring of additional labour, which was the second aspect of AWD considered more harmful to rice production.

This study showed that some sociodemographic characteristics were associated with the perception of benefits in applying AWD. Study participants who are more experienced in agriculture perceive more benefits from using AWD than farmers who have been working longer in rice cultivation. This result is compatible with other studies that showed that previous agricultural experience implies knowledge acquired over time and is essential in assessing technological innovations (LEBLANC *et al*., 2020).

Although knowledge about malaria is positively associated with a more favourable perception of AWD, more than 70% of producers did not identify combating the disease as a benefit explicitly associated with its adoption in rice crops. This result suggests that most producers have little knowledge about the reproductive cycle of vector mosquitoes and the role of AWDin interrupting this cycle. In addition, the farmers' observations and practical experiences with AWD, whether in their crops, in neighbours' plots or demonstration units, can make it challenging to understand the effects of the technique to reduce the risk of malaria transmission. Three factors can contribute to these difficulties: i) when AWD has applied alone in a small area, it may not be effective in significantly reducing adult mosquito populations, especially when neighbouring producers continue to keep their fields permanently flooded; ii) although the short periods without water in the crops are enough to eliminate the mosquito larvae, the efficiency of the technique in fighting malaria depends on the duration of the flooded periods, which, in cases of carelessness or lack of information by the producer, can allow the larval cycle to take place whenever it exceeds 8 days; and iii) during each phase of flooding in the rice fields, even those lasting less than 8

days, producers observe the proliferation of mosquito larvae, raising doubts about the effectiveness of the technique. In all, these results suggest that information campaigns on malaria should not be limited to the field of health but rather explicitly reinforce the links between strict agricultural water control practices and its direct effects on reducing vector-borne diseases.

The results revealed essential aspects about the role of communication channels in agriculture and health issues among farmers in the valley. The perception of benefits from the use of AWD was not associated with using any of the mass media as information on agriculture. Previous research reveals the importance of communication campaigns to promote sustainable practices in agriculture and health (MERTENS *et al*., 2017). However, this result suggests that formal communication channels have not been used to disseminate information about the advantages of AWD for productive activity.

On the other hand, the results show an active interpersonal discussion about agriculture among the study participants. They suggest that information about the benefits of AWD can circulate among male farmers who talk about the topic. In addition, men speak about agriculture more often with people outside the family than with their relatives. In general, these discussions are associated with a perception of benefits in the use of AWD, indicating that interpersonal communication with neighbours, friends, and agricultural technicians, who provide periodic advice to farmers, has the potential to expand the process of disseminating information that can foster adoption of the technique. Finally, the participation of producers in collective water management entities in the valley was also associated with more favourable perceptions about AWD. These entities are collaborative spaces for meetings and events that favour information about agricultural innovations and a better understanding of the benefits of new practices (HUAMANCHUMO *et al*., 2008).

Newspapers, magazines, and health books accessed in health centres, pharmacies, and churches seem to represent means of disseminating information favourable to AWD use. They can be used to spread knowledge about health that is reflected in the agricultural production methods in the region. The association between the perception of benefits of AWD and the discussion about health with members outside the family reinforces the idea that information on health regarding the use of AWD may have circulated during medical consultations or visits to health centres. The reasons why conversations on health with family members are associated with a more excellent perception of damage in the use of AWD deserve to be investigated.

5 CONCLUSION

The results show the relevance of integrating a more detailed analysis of farmers' perceptions of AWD's environmental, social and health impacts and the characterisation of factors associated with a favourable perception of its use in rice fields. This integrated analysis allows understanding of the producers' most relevant aspects, potentially facilitating and slowing down the adoption process, and how the interactions between these factors form the perceptions that guide decision-making.

The study showed that producers prioritise both the direct and purely economic implications and their indirect economic implications, focusing on environmental and human health. Developing new actions to promote AWD that link environmental and health issues with the economic priorities of producers, so that they are capitalised on by privileged communication networks, channels, and spaces for debate on the themes of agriculture and health, appears as a promising strategy to contribute to the sustainability of rice production in the Jequetepeque Valley.

The information generated in this work contributes to knowledge about strategies to promote agricultural practices that save water, which reflect in economic gains and allow reducing the socio-environmental and health vulnerability of populations and can be used by new research in the Jequetepeque Valley and in different regions that present similar epidemiological challenges, in contexts of water scarcity, environmental changes and climate uncertainty.

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Inovações complexas em agricultura, meio ambiente e saúde – as percepções de produtores de arroz do Vale do Jequetepeque, Peru

Complex innovations in agriculture, environment, and health – the perceptions of rice farmers in the Jequetepeque Valley, Peru

Renata Távora [1]
José Augusto Drummond [2]
Alain Santandreu [3]
Anita Luján [4]
Ernesto Ráez-Luna [5]
Ester Montalvan [6]
Elena Ogusuko [7]
Frédéric Mertens [8]

[1] *Doutorado em Desenvolvimento Sustentável, Pesquisadora, INCT-Odisseia, Universidade de Brasília, Brasília, DF, Brasil*
E-mail: renata.tavora@gmail.com

[2] *Doutorado em Recursos da Terra, Professor, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília, DF, Brasil*
E-mail: jaldrummond@uol.com.br

[3] *Licenciatura em Sociologia, Diretor Executivo, Consorcio por la Salud, Ambiente y Desarrollo (Ecosad), Lima, Peru*
E-mail: alain.santandreu@gmail.com

[4] *Licenciatura em Enfermaria, Professora, Universidad Nacional Mayor de San Marcos, Lima, Peru*
E-mail: alujang@unmsm.edu.pe

[5] *Mestrado em Estudos Latino-Americanos, Diretor Executivo, Instituto del Bien Común, Lima, Peru*
E-mail: eraez@ibcperu.org

[6] *Bacharelado em Ciências Sociais, Facilitador Social, Inerco, Piura, Ayabaca, Peru*
E-mail: montalvan.ts@hotmail.com

[7] *Bacharelado em Biologia, Dirección General de Salud Ambiental e Inocuidad Alimentaria, Ministerio de Salud, Lima, Peru*
E-mail: elenaoa2013@gmail.com

[8] *Doutorado em Ciências Ambientais, Professor, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília, DF, Brasil*
E-mail: mertens.br@gmail.com

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RESUMO

O aumento do uso de água nas monoculturas de arroz irrigado do Vale do Jequetepeque (costa norte do Peru) vem agravando problemas ambientais, socioeconômicos e de saúde. Nesse contexto, a Técnica de Irrigação com Secas Intermitentes (Tisi) oferece uma oportunidade de manejo mais eficiente da água no cultivo do arroz. O presente artigo buscou compreender as percepções dos agricultores sobre os benefícios e riscos do uso da Tisi. Dados de entrevistas com 319 agricultores mostraram que eles reconhecem as interações entre os aspectos econômicos, ambientais e de saúde, mas priorizam as questões econômicas para avaliar os benefícios da Tisi. Identificamos também os canais e espaços de comunicação privilegiados sobre os temas de agricultura e saúde com potencial de promover a difusão da Tisi. O estudo demonstrou a relevância de ações integradas para promover a adoção de inovações agrícolas, que considerem as interações entre sustentabilidade ambiental, questões de saúde e prioridades econômicas dos produtores.

Palavras-chave: Difusão de inovações. Agricultura. Arroz. Irrigação intermitente. Malária. Sustentabilidade.

ABSTRACT

The increased use of water in irrigated rice monocultures in the Jequetepeque Valley, on the northern coast of Peru, has exacerbated environmental, socioeconomic and health problems. The Alternate Wetting and Drying (AWD) irrigation technique aims to increase water management efficiency in rice cultivation. The objective of the present article is to understand farmers' perceptions about the benefits and risks of implementing AWD. Data from interviews with 319 farmers showed that they recognise nine interactions between AWD's economic, environmental and health aspects but prioritise economic factors when assessing its benefits. We also identified the main channels and spaces of communication and debate on issues related to agriculture and health that are likely to be effective in promoting the diffusion of AWD. The study demonstrated the relevance of integrated actions to encourage the adoption of agricultural innovations which consider the interactions between environmental sustainability, health issues, and producers' economic priorities.

Keywords: Diffusion of innovations. Agriculture. Rice. Intermittent irrigation. Malaria. Sustainability.

1 INTRODUÇÃO

Nas últimas décadas, a disponibilidade hídrica no Vale do Jequetepeque, localizado na costa norte do Peru, vem diminuindo gradativamente. Isso se deve, principalmente, ao sistema de monocultivo de arroz com irrigação permanente, que é a prática usual na região. Toda a costa norte é emblemática por suas condições geoclimáticas e, há vários milênios, sofre com recorrentes eventos extremos e adversos, ora de secas prolongadas, ora de chuvas excepcionais, que produzem efeitos generalizados, como a formação de dunas de areia e desertificação, bem como grandes inundações ao longo dos rios costeiros (GIRALT *et al*., 2007; RODRÍGUEZ-MORATA *et al*., 2019). Com isso, a agricultura é uma das atividades produtivas mais ameaçadas pelas mudanças no clima, trazendo incertezas e instabilidade econômica para os produtores da região (PERU, 2016).

A irrigação com inundação permanente gera outros problemas que contribuem para a vulnerabilidade das famílias de agricultores do vale, como o aumento da ocorrência de doenças vetoriais, entre elas a malária (GUTHMANN *et al*., 2002). A doença é considerada endêmica na região e o seu controle exige medidas preventivas, devido à relação direta entre a agricultura irrigada e a proliferação dos mosquitos vetores (IBARGÜEN, 2019). Nesse sentido, a adoção de práticas de cultivo e irrigação mais sustentáveis pode contribuir para uma produção agrícola mais eficiente em termos econômicos, menos vulnerável às mudanças climáticas e com menos riscos e danos ao meio ambiente e à saúde dos agricultores e suas famílias.

Em 2014, o Ministério da Saúde do Peru iniciou um projeto de pesquisa e intervenção, a fim de analisar a viabilidade da Técnica de Irrigação com Secas Intermitentes (Tisi) para promover a sustentabilidade da produção de arroz do Vale do Jequetepeque. Essa prática foi desenvolvida na Ásia há cerca de

300 anos. No entanto, somente a partir das últimas quatro décadas que ela vem sendo sistematizada por grupos de pesquisa internacionais e difundida para outros continentes e países, incluindo o Peru (KEISER; UTZINGER; SINGER, 2002; PERU, 2002). Ela consiste em um manejo mais eficiente da irrigação no cultivo do arroz, a partir da aplicação de períodos controlados de secas, em substituição à irrigação permanente. A Tisi é considerada uma inovação complexa, pois tem implicações multidimensionais, entre elas: (i) socioeconômicas, pela redução dos custos de produção; (ii) ambientais, por conta de um manejo mais adequado da água e da proteção do solo; e (iii) de saúde, pela redução do *habitat* dos mosquitos vetores de doenças (PERU, 2012).

Apesar das evidências científicas sobre os impactos socioeconômicos, ambientais e de saúde, a Tisi ainda não foi amplamente adotada pelos produtores de arroz da costa norte peruana. Entender as percepções dos agricultores sobre os benefícios e riscos de aplicação da Tisi é essencial para compreender as oportunidades e desafios para sua adoção em larga escala. Este artigo tem como objetivo compreender os fatores que podem favorecer ou dificultar a implementação da Tisi, a partir das percepções dos produtores de arroz do Vale do Jequetepeque, sobre suas características socioeconômicas, ambientais e de saúde.

A seguir, é apresentada uma revisão das evidências científicas sobre os benefícios e limitações da Tisi, e sobre os fatores que estão frequentemente associados às percepções de inovações agrícolas.

1.1 A TÉCNICA DE IRRIGAÇÃO COM SECAS INTERMITENTES (TISI)

Nas últimas quatro décadas, diversos grupos de pesquisa e agências internacionais vêm sistematizando práticas alternativas de cultivo do arroz, que integram o controle de diferentes regimes de irrigação, também chamadas de "técnicas para economia de água" (*water-saving techniques* ou *water-saving technology*) (HUMPHREYS *et al.*, 2005). Elas buscam reduzir o uso de água na irrigação e aumentar a eficiência do seu uso, sem comprometer a produtividade dos cultivos. Uma dessas tecnologias é a Técnica de Irrigação com Secas Intermitentes (Tisi), também conhecida como "irrigação intermitente" (*intermittent irrigation*) ou "técnica de manejo da água com alternância entre irrigação e secagem" (AWD, sigla em inglês para *alternate wetting and drying*).

Um grande número de estudos realizado em diversos países vem consolidando um corpo robusto de resultados sobre a Tisi, descrevendo os seus múltiplos benefícios e limitações (ENRIQUEZ *et al*., 2021). No Peru, os estudos realizados a partir dos anos 2000 tiveram um enfoque integrado sobre os aspectos econômicos e de saúde, incluindo a dimensão ambiental, além de um forte componente participativo, com estratégias de difusão, comunicação e regulamentação política sobre o cultivo do arroz no país (CHÁVEZ, 2007; PERU, 2002, 2011, 2012; VÉLEZ, 2008). Dessa forma, a Tisi pode ser caracterizada a partir de suas propriedades multidimensionais, que intervêm simultaneamente sobre aspectos socioeconômicos, ambientais e de saúde.

Pesquisas anteriores apontam diversos benefícios socioeconômicos da implementação de regimes de irrigação com secas intermitentes no cultivo do arroz (ALEN; SANDER, 2019). Na costa norte do Peru, os estudos realizados demonstraram que a Tisi aumentou a produtividade por hectare entre 20% e 25%, podendo, assim, diminuir a competição entre os agricultores pelos recursos (CHÁVEZ, 2007; PERU, 2002). Além disso, a Tisi permite reduzir os custos da produção, pois melhora a eficiência no uso da água, reduzindo as despesas com irrigação, que estão, geralmente, incluídas nos cálculos de rendimentos dos cultivos de arroz (ALAUDDIN *et al*., 2020). No Peru, em 2006, um estudo de validação da Tisi, realizado pelo Ministério da Saúde em um distrito próximo ao Vale do Jequetepeque, verificou uma economia de 35% da água de irrigação por hectare (PERU, 2011).

Por outro lado, a aplicação da Tisi também apresenta algumas implicações negativas no âmbito econômico. Uma delas é a necessidade de um maior controle de ervas daninhas e de outras doenças que surgem quando não há irrigação contínua (ISHFAQ *et al*., 2020). Isso provoca um aumento nos custos

de mão de obra para o controle e remoção dessas pragas. No entanto, alguns ajustes podem contornar o problema, entre eles combinar a aplicação de herbicidas pré-emergentes com a manutenção de água rasa por 10 a 15 dias após o transplante. Esse método pode atrasar o período de secagem dos cultivos, mas é útil para o controle de ervas daninhas, pois aumenta a eficácia do herbicida, além de permitir que a planta se recupere do choque do transplante (MUBEEN; JABRAN, 2019).

Em relação à dimensão ambiental, as pesquisas relatam contribuições importantes da Tisi na mitigação dos principais impactos ambientais conexos ao cultivo do arroz. Os cultivos permanentemente irrigados são uma fonte significativa de metano (CH_4), um dos principais Gases de Efeito Estufa (GEE), e contribuem com 10% das emissões agrícolas globais de CH_4 (ENRIQUEZ *et al*., 2021). Por conta de um controle mais rigoroso dos volumes de água para irrigação, a Tisi pode reduzir as emissões de CH_4 em 48% a 93%. Outros estudos analisaram a redução das emissões de óxido nitroso (N_2O), outro tipo de GEE emitido pelos campos de arroz, em decorrência do uso excessivo de fertilizantes nitrogenados (BALAINE *et al*., 2019). Além disso, a Tisi permitiu corrigir as deficiências nutricionais dos solos de forma natural, com o aumento da atividade microbiana e da macrofauna (minhocas e outros invertebrados), que ressurgem em condições aeróbicas, estimulando a ciclagem de nutrientes orgânicos (ALEN; SANDER, 2019).

O monitoramento dos regimes de irrigação também reduz a degradação do solo ocasionada pela lixiviação de nutrientes e pela salinização. A irrigação tradicional provoca o afloramento dos sais presentes no solo, reduzindo a produtividade dos cultivos (GORDON; FINLAYSON; FALKENMARK, 2010). A aplicação da Tisi reduz a saturação desses campos, bem como os problemas de fertilidade do solo (HUMPHREYS *et al.*, 2005).

Além disso, a monocultura de arroz tem uma alta dependência de insumos externos e agroquímicos, como fertilizantes químicos, inseticidas, fungicidas e herbicidas, que provocam uma contaminação generalizada dos ecossistemas e aumentam os riscos para a saúde dos trabalhadores (MACHER; LUNA, 2016). Diversos estudos relataram que a Tisi pode reduzir a contaminação do ambiente e a exposição humana, pois prevê a adoção de critérios mais seletivos no uso desses produtos (ALEN; SANDER, 2019).

No âmbito da saúde, a Tisi apresenta como principal benefício a redução da incidência de doenças vetoriais, por conta da eliminação dos criadouros dos mosquitos vetores da malária (*Anopheles albimanus*) e de outras enfermidades, como o *Aedes aegypti* (transmissor da dengue, da febre amarela, da febre chikungunya e do zika vírus) e o *Culex* spp. (vetor de várias encefalites virais) (KEISER; UTZINGER; SINGER, 2002). A aplicação de períodos de secas interrompe o ciclo reprodutivo desses vetores durante o estágio larval aquático (KIBRET *et al.*, 2018). Os estudos na costa norte do Peru constataram que a Tisi reduziu consideravelmente (entre 86% e 93%) a população das larvas do mosquito transmissor da malária (CHÁVEZ, 2007; PERU, 2002, 2011, 2012).

Apesar dos benefícios econômicos, ambientais e de saúde, uma implementação bem-sucedida da Tisi depende de outros fatores e condições locais, que interagem com as características próprias da inovação e influenciam as percepções dos agricultores. A seguir, apresentamos diversas categorias de fatores relevantes para compreender a percepção dos agricultores sobre inovações agrícolas.

1.2 OS FATORES ASSOCIADOS ÀS PERCEPÇÕES SOBRE INOVAÇÕES AGRÍCOLAS

O processo de adoção de novas ideias, práticas ou comportamentos na produção agrícola está condicionado a uma série de fatores que podem influenciar a percepção dos agricultores sobre os benefícios e os riscos das inovações (ROGERS, 2003). São reconhecidas três grandes categorias de fatores que podem afetar as percepções e a adoção de uma inovação agrícola (MEIJER *et al.*, 2015):

I. as características dos produtores agrícolas, ou seja, seus perfis sociodemográficos, suas atuações em espaços coletivos de decisões políticas e associativismo, e os conhecimentos e experiências adquiridos sobre seus contextos produtivos e sobre as problemáticas ambientais e de saúde;

II. as características do sistema produtivo, que incluem informações referentes à propriedade agrícola, aos modos de cultivo e às despesas da produção; e

III. os canais de comunicação, formais e informais, que conformam as diversas fontes de informação utilizadas pelos produtores sobre temas relevantes para suas atividades agrícolas.

A seguir, detalhamos esses três grupos de fatores, com foco na sua relevância para as percepções dos produtores do Vale do Jequetepeque sobre a Tisi.

1.2.1 CARACTERÍSTICAS DOS PRODUTORES AGRÍCOLAS

Há um reconhecimento crescente da importância de compreender os papéis de gênero na formação das percepções sobre inovações complexas, que envolvem múltiplas dimensões: socioeconômicas, ambientais e de saúde. As diferenças nos interesses, nas experiências e nas funções culturalmente atribuídas a mulheres e homens em um determinado contexto social resultam em diferentes decisões e comportamentos sobre diversas temáticas (SAINT-CHARLES *et al.*, 2012). Os homens frequentemente ponderam suas decisões sobre a adoção de uma inovação, preferencialmente em função dos seus benefícios econômicos e das contribuições para a renda familiar (PHIRI *et al.*, 2004), enquanto as decisões de mulheres são tomadas com base na percepção de risco e de suas vulnerabilidades, levando a comportamentos preventivos em saúde (MERTENS *et al.*, 2005, 2017) e de adaptação às mudanças ambientais e climáticas (JIN; WANG; GAO, 2015).

A idade, a escolaridade e a experiência na atividade agrícola são amplamente reconhecidas como variáveis de capital humano que podem afetar as decisões no processo de adoção (PROKOPY *et al.*, 2008). Por exemplo, o aumento da idade pode ter uma relação negativa com a mudança tecnológica, ou seja, quanto mais velhos os agricultores, mais avessos se tornam a um eventual risco e mais resistem a uma nova prática (KABII; HORWITZ, 2006). No entanto, outros autores apontaram que agricultores mais experientes tendem a ser mais eficientes na incorporação de novas tecnologias e têm maior probabilidade de entender benefícios de inovações agrícolas (LEBLANC *et al.*, 2020). Além disso, os agricultores com níveis mais altos de educação tendem a ter maior probabilidade de adotar tecnologias agrícolas que demandam habilidades técnicas avançadas (BAUMGART-GETZ; PROKOPY; FLORESS, 2012).

A participação dos agricultores em associações, comissões, conselhos, entre outros espaços decisórios, pode contribuir para a adoção de práticas inovadoras e mais sustentáveis (BODIN; CRONA, 2008; OSTROM, 2000). A legitimidade da participação dos agricultores pode favorecer um planejamento e gerenciamento mais eficazes dos sistemas de irrigação e potencializar mudanças nas percepções dos agricultores sobre os benefícios das inovações, como no caso da Tisi (FULAZZAKY, 2017; PALIS *et al.*, 2017).

1.2.2 CARACTERÍSTICAS DO SISTEMA PRODUTIVO

O tamanho da fazenda e a multifuncionalidade da propriedade, ou seja, a diversificação de atividades rentáveis além da agricultura como, por exemplo, a provisão de materiais ou serviços da produção, ou a criação de animais e sua comercialização, podem favorecer a percepção de benefícios e a adoção de inovações agrícolas (CASWELL *et al.*, 2001; MANSON *et al.*, 2014). A disponibilidade de financiamento também influencia positivamente o processo de adoção, porque o acesso ao capital permite uma maior capacidade de experimentar uma nova prática. Outro fator importante está relacionado às despesas da produção, pois algumas práticas demandam menos mão de obra e insumos durante o cultivo ou são mais eficientes no uso da água, reduzindo o custo total da produção (PROKOPY *et al.*, 2008).

1.2.3 CANAIS DE COMUNICAÇÃO FORMAIS E INFORMAIS

Segundo Rogers (2003), um canal de comunicação é o meio pelo qual as mensagens são transmitidas de um indivíduo para outro. Eles podem influenciar as percepções dos indivíduos, pois permitem reduzir a incerteza sobre determinada inovação, favorecendo sua adoção. A comunicação pode seguir canais formais, como mídias de massa, ou informais, por meio das relações interpessoais (MERTENS *et al.*, 2017). As mídias de massa incluem o rádio, a televisão, os jornais e a Internet, com potencial de alcançar um público amplo e difundir informações relevantes para as práticas agrícolas. As relações de comunicação interpessoal costumam contribuir para além da difusão de informações, uma vez que as mensagens transmitidas são discutidas e interpretadas de acordo com os contextos sociais e culturais dos indivíduos (VALENTE; FOSADOS, 2006).

Os padrões de comunicação interpessoal são muitas vezes diferentes entre homens e mulheres. As discussões sobre questões de saúde ou temas socioambientais tendem a formar vias de difusão que conectam preferencialmente pessoas do mesmo gênero (BURGOS; MERTENS, 2017; TRIANA *et al.*, 2016). No entanto, as relações entre homens e mulheres são essenciais para a adoção de práticas sustentáveis que requerem uma implementação coletiva no lar ou no grupo familiar (MERTENS; SAINT-CHARLES; MERGLER, 2012).

2 METODOLOGIA

2.1 MODELO DE ANÁLISE

Com base na revisão dos principais conjuntos de fatores apresentados na introdução, a Figura 1 ilustra o quadro analítico elaborado para analisar as percepções dos agricultores em relação às propriedades multidimensionais da Tisi (econômicas, ambientais e de saúde) e como as características dos produtores agrícolas, do sistema produtivo e os canais de comunicação podem estar associados à percepção de benefícios sobre a Tisi.

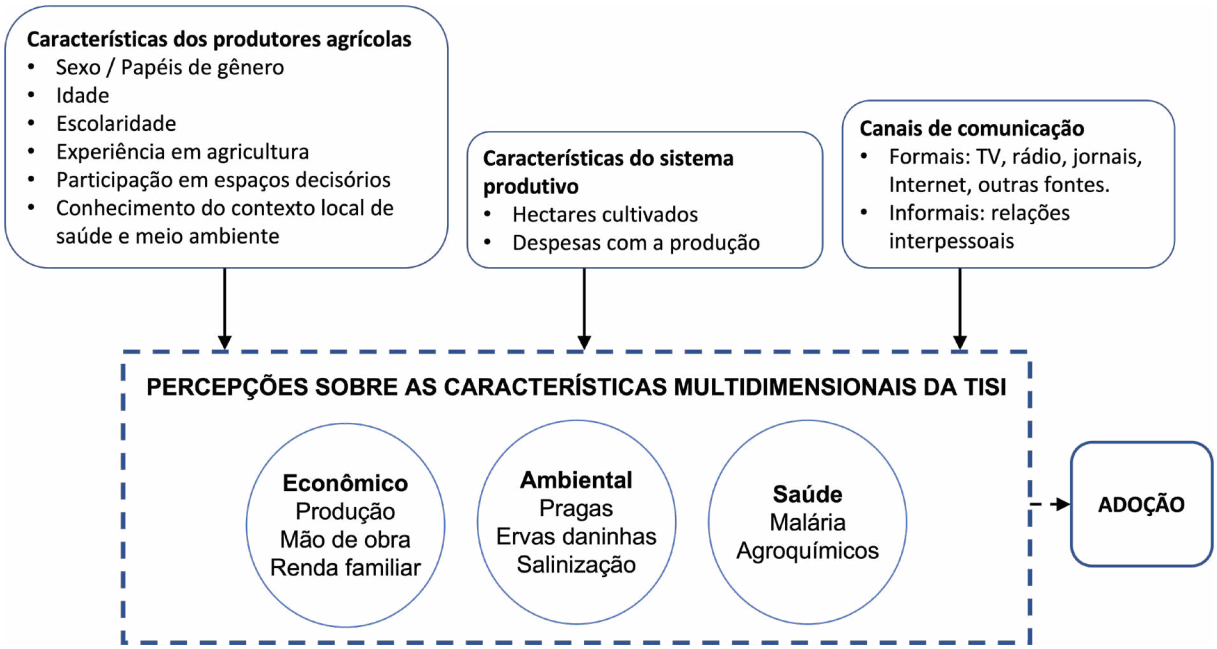

Figura 1 | Quadro analítico elaborado para testar as associações entre os fatores associados às percepções dos agricultores sobre a Tisi.

Fonte: Elaboração própria..

2.2 ÁREA DE ESTUDO

A área de estudo está inserida na bacia do Rio Jequetepeque, localizada na costa norte do Peru, distante aproximadamente 645 km da capital Lima. As áreas de produção de arroz mais importantes da região encontram-se no Vale do Jequetepeque, situado na parte baixa da bacia, desde a represa Gallito Ciego até a desembocadura do rio no mar (Figura 2). O vale tem uma área aproximada de 227.000 hectares (32,5% da bacia), dos quais 42.800 são cultiváveis. Em 2017, a população residente era de 181.315 habitantes, vivendo tanto em zonas urbanas (91,7%) quanto na área rural (8,3%) (INEI, 2018). Essa região é uma zona hiperárida, caracterizada por chuvas reduzidas e altas taxas de evaporação. O clima é reconhecido como predominantemente quente e seco, com precipitação média anual de 150 mm e temperatura média anual de 24°C (PERU, 2016). Portanto, a existência de uma agricultura em larga escala é altamente dependente da infraestrutura de irrigação e do gerenciamento adequado para distribuição e uso da água.

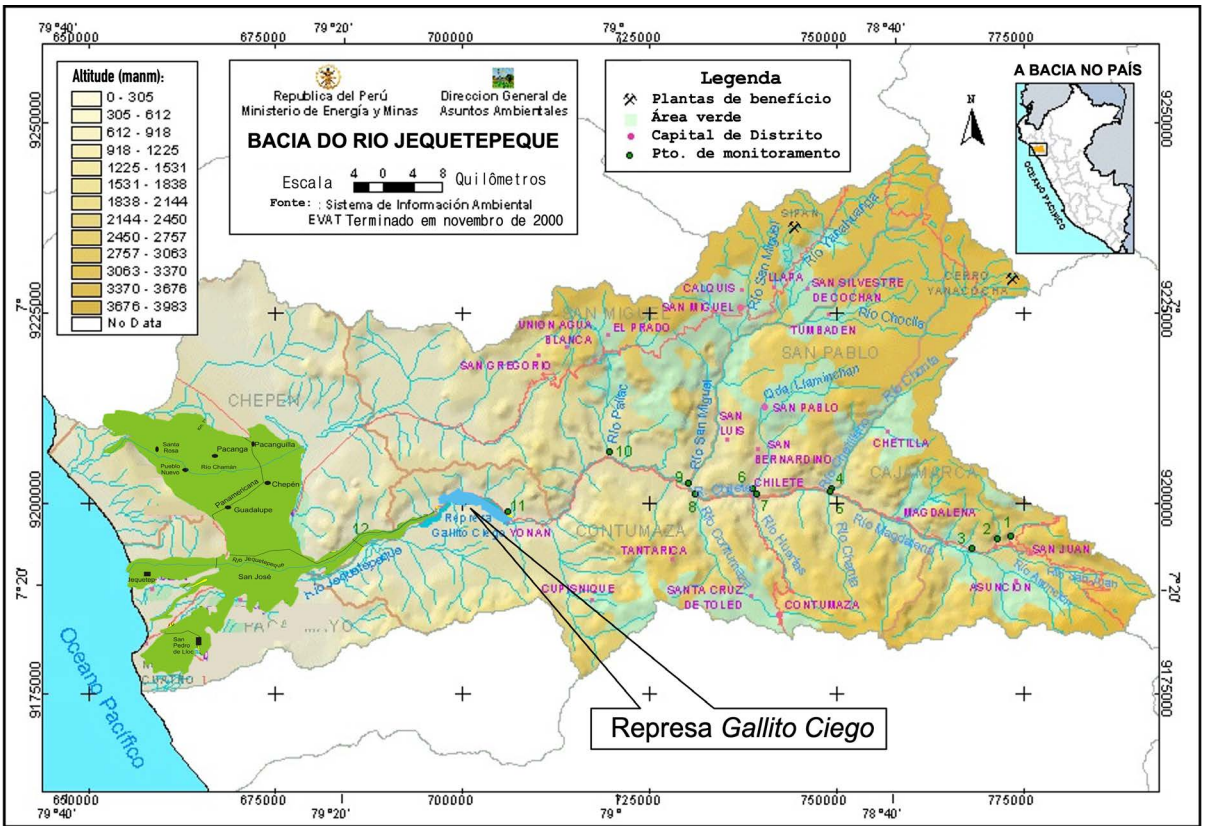

Figura 2 | Bacia do Rio Jequetepeque, com destaque para a Represa Gallito Ciego e o Vale do Jequetepeque (em verde).

Fonte: (PERU, 2000) (adaptada).

Os agricultores do vale estão organizados em diferentes entidades de gestão coletiva da água. A principal é a *Junta de Usuarios del Agua del Valle del Jequetepeque* (JUAVJ), que reúne um total de 15.072 agricultores cadastrados. A JUAVJ é uma instituição sem fins lucrativos, que opera e mantém a infraestrutura hidráulica do vale. Ela administra a água de maneira descentralizada, por meio de 14 Comissões de Irrigação, responsáveis, por sua vez, por uma série de setores hidráulicos, subdivididos em Comitês de Irrigação, que organizam a distribuição da água para os lotes dos produtores (GUERRERO-PADILLA, 2015; HUAMANCHUMO *et al.*, 2008).

2.3 POPULAÇÃO DE ESTUDO

Foi definida uma amostra da população de estudo com base nos dados fornecidos pela JUAVJ sobre o total de agricultores, maiores de idade, cadastrados como usuários da água para irrigação e que residem na parte baixa da bacia do Rio Jequetepeque (10.072 produtores). Esse cálculo utilizou a fórmula de amostragem aleatória para proporções, considerando um nível de confiança de 95% e uma taxa de 10% de não resposta. Com isso, a amostra aproximada da população de estudo foi de 412 agricultores. Em seguida, foi realizada a distribuição proporcional ao tamanho dos estratos, ou seja, da população de cada uma das 14 Comissões de Irrigação do Vale do Jequetepeque.

Dentro das considerações éticas do projeto, foi realizado um grande evento coletivo, com a participação da JUAVJ e seus agricultores associados. Nessa ocasião, foram apresentadas as diferentes fases da pesquisa, entre elas as etapas experimentais, nas quais os produtores se informaram sobre os benefícios e possíveis dificuldades de aplicação da Tisi, e puderam se candidatar a destinar parcelas de suas áreas de cultivo ao estudo. Foram informados também sobre as etapas de entrevistas, que seriam conduzidas pela equipe identificada do projeto, sendo considerada a participação voluntária, com um consentimento prévio informado de cada produtor e o anonimato das informações prestadas para salvaguardar a segurança e a dignidade dos participantes.

Dessa forma, durante os meses de junho e julho de 2014, entrevistas semiestruturadas foram conduzidas para aplicação de um questionário a um total de 372 agricultores, das quais 53 foram descartadas por conterem dados incompletos, resultando em uma amostra final de 319 agricultores de todo o vale.

2.4 VARIÁVEIS

Foram coletados dados sobre os três grupos de fatores definidos no quadro analítico (Figura 1):

I. Características dos produtores agrícolas: dados sociodemográficos (sexo, faixa etária, escolaridade e anos de experiência na agricultura do arroz), participação nas organizações de gestão coletiva da água (JUAVJ e os Comitês de Irrigação) e conhecimentos sobre os aspectos de transmissão e prevenção da malária, diferenciando os participantes que desconhecem o assunto, os que conhecem apenas um aspecto (transmissão ou prevenção) e os que apresentam conhecimento sobre ambos os aspectos;

II. Características do sistema produtivo: incluem o tamanho da área cultivada (em hectares) e as despesas com mão de obra e compra de insumos (fertilizantes e pesticidas). Os dados coletados se referem à safra de 2013-2014;

III. Canais de comunicação utilizados para obter informações sobre os temas de agricultura e saúde, sendo eles: formais, referentes ao uso das mídias de massa (televisão, rádio, jornais e Internet) e informais, referentes às redes de comunicação interpessoal, mapeadas a partir da identificação das pessoas com quem os participantes declararam ter conversado sobre cada tema. Os entrevistados puderam mencionar quantas pessoas quisessem. Ambas as redes de discussão (sobre agricultura ou sobre saúde) foram caracterizadas de acordo com seu tamanho (número de pessoas com quem o participante conversou), composição de gênero (número de mulheres/homens com quem conversou) e composição familiar (número de pessoas da família ou externas à família com quem conversou). Os indivíduos externos à família poderiam ser vizinhos, amigos, colegas de trabalho, técnicos agrícolas, profissionais de saúde, entre outros.

2.5 AS CARACTERÍSTICAS MULTIDIMENSIONAIS DA TISI E A CONSTRUÇÃO DO ÍNDICE DE PERCEPÇÃO DE BENEFÍCIOS

A percepção dos participantes sobre os benefícios e riscos da adoção da Tisi foi analisada por meio da pergunta *"Na sua opinião, indique, entre as opções abaixo, de que maneira a Tisi pode afetar o cultivo de arroz em sua propriedade*". Uma lista de oito aspectos foi apresentada ao participante: (e) econômicos, entre eles, produção de arroz (ha), renda familiar e mão de obra empregada; (a) ambientais, referentes à salinização do solo, à presença de pragas e ao aparecimento de ervas daninhas; e (s) de saúde, referente à ocorrência da malária e ao uso de pesticidas. Para cada aspecto o participante indicou se a Tisi poderia "beneficiar", "prejudicar", "ser indiferente" ou "não sabe opinar".

As respostas individuais foram usadas para construir um Índice de Percepção dos Benefícios. Para cada aspecto apresentado, as respostas foram pontuadas da seguinte forma: zero, um ou dois pontos, quando o participante identificou respectivamente prejuízos, ausência de efeito/não soube opinar ou benefícios associados à adoção da Tisi. Os pontos atribuídos a cada característica foram somados e os participantes divididos em dois grupos, com percepção predominantemente negativa (entre 0 e 8 pontos) ou positiva (entre 9 e 16 pontos) quanto aos efeitos da adoção da Tisi.

2.6 ANÁLISES ESTATÍSTICAS

As análises estatísticas descritivas incluem distribuições de frequência, médias e intervalos. Os dados foram desagregados por gênero para identificar as possíveis diferenças entre os homens e as mulheres da população de estudo (testes Chi-quadrado ou t-Student). O Índice de Percepção dos Benefícios foi integrado em modelos de regressão logística bivariada, a fim de verificar as possíveis associações entre os fatores dos três grupos analisados e a percepção de benefícios sobre a Tisi (HOSMER; LEMESHOW, 2000).

3 RESULTADOS

3.1 OS AGRICULTORES DO VALE DO JEQUETEPEQUE

A Tabela 1 apresenta dados sobre as características dos participantes do estudo, que totalizaram 287 homens e 32 mulheres, e do sistema produtivo. A idade dos entrevistados variou entre 21 e 90 anos, com média elevada, de 59 anos. Mais da metade dos participantes (65,9%) tem grau de escolaridade entre o primário e secundário, com média de sete anos de duração total em estudos formais. O tempo de dedicação à agricultura do arroz é, em média de 26 anos, sendo que os homens apresentam anos de experiência significativamente maior do que das mulheres ($p = 0,0004$).

Com relação à participação nas entidades de gestão coletiva da água, os agricultores participam, em maior número, dos Comitês de Irrigação locais (56,4%), comparado à organização regional do Vale do Jequetepeque (JUAVJ) (39,5%). Pouco mais da metade dos participantes do estudo (50,8%) tem conhecimento sobre transmissão e prevenção da malária, sendo que apenas 9% das mulheres desconhecem o assunto, contra 22% dos homens. Finalmente, 52% dos participantes possuem percepção predominantemente positiva quanto aos efeitos da adoção da Tisi. Não existe diferença significativa entre os grupos de homens e mulheres.

Os participantes cultivaram na safra 2013/2014, em média, 4,4 hectares, com ampla variação entre eles (1 a 43 hectares). Os homens cultivam, em média, terrenos significativamente maiores do que as mulheres ($p = 0,0207$). A maioria dos participantes declarou ter despesas com compra de fertilizantes (73%), de pesticidas (72,7%) ou com pagamento de mão de obra (71,8%).

Tabela 1 | Distribuição de frequência das características dos agricultores e sistema produtivo, dos conhecimentos sobre malária e as percepções de benefícios da Tisi para o cultivo do arroz.

	Total (%)	*Homem (%)*	*Mulher (%)*
Idade			
21-30	2,8	2,8	3,1
31-40	7,2	7,7	3,1
41-50	15,7	14,6	25,0
51-60	27,0	26,1	34,4
61-70	26,6	28,9	6,3
71-80	16,6	15,7	25,0
81-90	4,1	4,2	3,1
Escolaridade (anos)			
Primário (0-5)	40,8	40,5	43,8
Secundário (6-10)	25,1	24,7	28,1
Superior (11-15)	30,4	30,7	28,1
Pós-graduação (16-18)	3,8	4,2	0
Experiência na agricultura (anos)			
1-10	19,4	17,1	40,6
11-20	24,5	25,4	15,6
21-30	30,4	32,1	15,6
31-40	10,0	9,1	18,8
41-50	7,2	7,3	6,3
51-60	6,0	6,6	0,0
61-70	2,2	2,4	0,0
71-80	0,3	0,0	3,1
Participação na gestão da água*			
JUAVJ	39,5	40,1	34,4
Comitês de Irrigação	56,4	57,1	50,0
Conhecimento sobre transmissão e prevenção da malária			
Não conhece	21,3	22,6	9,4
Conhece um dos aspectos	27,9	28,2	25,0
Conhece os dois aspectos	50,8	49,1	65,6
Percepções dos benefícios da Tisi			
Percebe poucos benefícios	48,0	48,4	43,8
Percebe benefícios	52,0	51,6	56,3
Total de hectares (ha) cultivado**			
Média / DP / Intervalo	4,4 / 5,2 / 0-43	4,6 / 5,4 / 0-43	2,4 / 1,6 / 0,5-5,5
Despesas com a produção			
Compra de fertilizantes	73,0	72,8	75,0
Compra de pesticidas	72,7	72,5	75,0
Mão de obra	71,8	71,8	71,9

** Chi-Square (p = 0,0004); ** T-test (p = 0,0207)*
Fonte: Elaboração própria (dados de pesquisa de campo).

A Tabela 2(a) apresenta as frequências do uso, pelos participantes, das principais mídias de massa para obter informações sobre os temas relacionados à atividade agrícola e à saúde. Um pouco mais da metade dos participantes utiliza a televisão (52,4%) e o rádio (50,8%) para obter informações sobre agricultura. Os homens usam o rádio com uma frequência significativamente mais alta (53%) do que as mulheres (31,3%). Jornais (8,5%) e Internet (3,1%) são utilizados por poucos entrevistados. Outras

fontes de informação foram indicadas por 31% dos participantes do estudo, sendo elas: informativos oferecidos pelas diversas comissões de irrigação, materiais distribuídos por outras entidades do governo local, da JUAVJ, de empresas agroindustriais (Bayer, Farmex e Tecuse) e do comércio de insumos.

Em relação ao tema da saúde, quase 3/4 dos participantes utiliza a televisão como principal fonte de informação (71,5%). Em segundo e terceiro lugares estão o rádio (23,5%) e outras fontes de informação (20,7%). Estas últimas são oferecidas por ocasião de consultas nos postos e centros de saúde, em farmácias, em escritórios de Seguro Social de Saúde Municipal, nas escolas dos filhos, pelo Ministério da Saúde, por revistas e livros de saúde ofertados por médicos e em igrejas. O uso de jornais e Internet é menos frequente: apenas 13,5% e 3,1%, respectivamente, dos participantes os consultam, sendo esta última usada apenas por homens.

Tabela 2 | Uso dos canais de comunicação (a) formais e (b) informais, para obter informações sobre agricultura e saúde.

(a) Canais Formais			
	Total (%)	*Homem (%)*	*Mulher (%)*
Agricultura			
TV	52,4	52,3	53,1
Rádio*	50,8	53,0	31,3
Jornais	8,5	8,7	6,3
Internet	3,1	3,5	0,0
Outras fontes	31,0	31,4	28,1
Saúde			
TV	71,5	70,4	81,3
Rádio*	23,5	24,4	15,5
Jornais	13,5	13,2	15,6
Internet	3,1	3,5	0,0
Outras fontes	20,7	20,6	21,9

(b) Canais Informais							
	Total			*Homem*		*Mulher*	
Discussão interpessoal em agricultura	***Média***	***DP***	***Intervalo***	***Média***	***DP***	***Média***	***DP***
Número de indivíduos	3,8	2,2	0-11	3,9	2,3	3,3	1,6
Número de homens**	3,6	2,2	0-11	3,7	2,2	2,8	1,6
Número de mulheres***	0,2	0,5	0-4	0,2	0,4	0,6	0,9
Número de familiares	0,5	0,8	0-4	0,4	0,8	0,6	0,8
Número de externos à família	3,3	2,2	0-11	3,4	2,2	2,2	1,7
Discussão interpessoal em saúde	***Média***	***DP***	***Intervalo***	***Média***	***DP***	***Média***	***DP***
Número de indivíduos	2,4	1,5	0-6	2,4	1,6	2,2	0,9
Número de homens	1,6	1,2	0-6	1,6	1,3	1,5	1,0
Número de mulheres	0,8	0,9	0-4	0,8	0,9	0,7	0,7
Número de familiares	0,9	1,2	0-6	0,9	1,3	1,1	1,1
Número de externos à família	1,4	1,3	0-6	1,5	1,4	1,1	0,2

*Chi-square (p<0,05); **Anova (p<0,05); *** Anova (p<0,0001)*
Fonte: Elaboração dos autores (dados de pesquisa de campo).

A Tabela 2(b) apresenta os dados de comunicação interpessoal sobre agricultura e saúde, entre homens e mulheres participantes do estudo. O número de indivíduos com quem homens e mulheres conversam sobre agricultura é parecido, em média 3,9 pessoas e 3,3 pessoas, respectivamente. Tanto os homens quanto as mulheres conversam, em média, com um maior número de homens do que de mulheres. No entanto, os homens conversam significativamente mais que as mulheres com outros homens, enquanto as mulheres conversam significativamente mais que os homens com outras mulheres. A discussão sobre práticas agrícolas ocorre com maior frequência com pessoas externas ao núcleo familiar, em média 3,3, do que com pessoas da mesma família, em média 0,5.

Sobre o tema da saúde, em média, homens e mulheres conversam com um número semelhante de pessoas, sendo que ambos conversam preferencialmente com homens sobre o tema. Os homens conversam sobre o tema da saúde preferencialmente com indivíduos externos à família, enquanto as mulheres conversam nas mesmas proporções com pessoas externas à família e com membros da família.

3.2 A PERCEPÇÃO DOS AGRICULTORES SOBRE OS BENEFÍCIOS DA ADOÇÃO DA TISI PARA O CULTIVO DO ARROZ

A Figura 3 apresenta as porcentagens dos indivíduos que consideram que a Tisi traz benefícios, prejuízos ou é indiferente em relação aos aspectos econômicos (e), ambientais (a) e de saúde (s) na atividade de cultivo de arroz. A característica da Tisi considerada vantajosa com maior frequência está relacionada com a redução da ocorrência de pragas (65%). Em segundo lugar, muitos participantes (59%) consideram positivo que a Tisi permita reduzir o consumo de agroquímicos. O terceiro benefício mais apontado (44%) diz respeito ao aumento da produção de arroz. Os aspectos da Tisi considerados mais prejudiciais para o cultivo do arroz são o controle de ervas daninhas (66%) e a necessidade de empregar mais mão de obra (37%). Isso se deve ao fato de que os períodos de secas propiciam o aparecimento de plantas oportunistas que competem com o arroz pelos nutrientes do solo, trazendo prejuízos para a produção, e cuja remoção exige considerável mão de obra para a capina manual. Muitos participantes (63%) não identificaram benefícios nem prejuízos quanto à aplicação da Tisi no que toca à incidência da malária, provavelmente por desconhecerem que a seca interrompe o ciclo larval dos mosquitos vetores da doença. O papel da aplicação da Tisi para redução da salinização dos solos também não foi reconhecido pela maioria dos participantes.

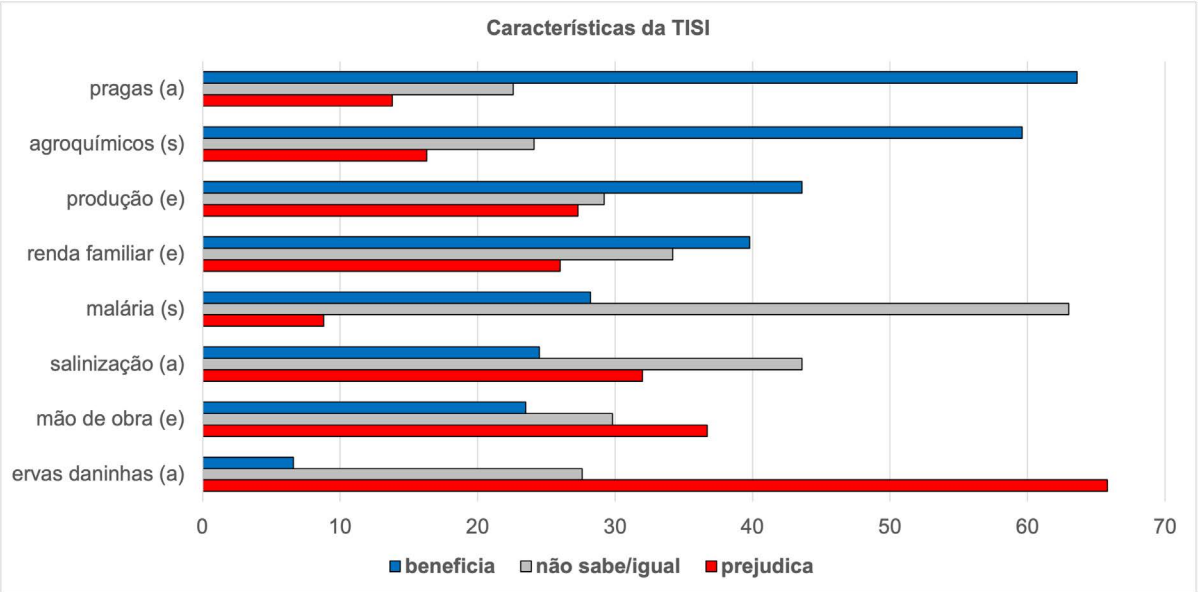

Figura 3 | Porcentagens dos participantes que consideram que a Tisi traz benefícios, prejuízos ou é indiferente/não sabe opinar quanto aos aspectos ambientais (a), econômicos (e) e de saúde (s).

Fonte: Elaboração própria (dados de pesquisa de campo).

3.3 OS FATORES ASSOCIADOS ÀS PERCEPÇÕES DE BENEFÍCIOS DO USO DA TISI PARA O CULTIVO DO ARROZ

A Tabela 3 apresenta os resultados das regressões logísticas bivariadas que mostram a probabilidade de associação entre as características dos agricultores e dos sistemas produtivos, os canais de comunicação e a percepção predominantemente positiva quanto aos efeitos da Tisi para o cultivo do arroz. O tempo de experiência na agricultura e a participação nas duas entidades de gestão da água estiveram associados a uma maior probabilidade de reconhecer os benefícios da Tisi. As despesas com mão de obra, compra de fertilizantes e de pesticidas, assim como o grau de conhecimento sobre transmissão e prevenção da malária, também estiveram associados a uma percepção preferencialmente benéfica da Tisi para o cultivo do arroz. As outras variáveis não mostraram associação significativa.

Tabela 3 | Regressões logísticas bivariadas que mostram a probabilidade de associação entre as características dos produtores e do sistema produtivo, os canais de comunicação e a percepção predominantemente positiva da Tisi para o cultivo do arroz.

Modelos Bivariados	*Razão de Possibilidades (odd ratio)*	*p*
Características dos produtores agrícolas		
Sexo	0,828	0,6154
Idade	1,004	0,6342
Escolaridade	1,009	0,7246
Experiência na agricultura	1,025	0,0150
Participa da JUAVJ	2,867	<0,0001
Participa dos Comitês de Irrigação	2,457	0,0001
Conhecimento sobre malária	1,807	<0,0001
Características do sistema produtivo		
Total de hectares cultivado	0,974	0,2551
Compra de fertilizantes	2,444	0,0006
Compra de pesticidas	2,514	0,0004
Mão de obra	2,393	0,0007
Canais de comunicação formais em agricultura		
TV	0,956	0,8395
Rádio	0,805	0,3352
Jornais	0,608	0,2231
Internet	0,605	0,4432
Outras fontes	0,970	0,9003
Canais de comunicação formais em saúde		
TV	1,229	0,4054
Rádio	0,755	0,2878
Jornais	2,698	0,0059
Internet	0,605	0,4432
Outras fontes	0,525	0,0221
Discussão interpessoal em agricultura		
Número de indivíduos	1,150	0,0082
Número de homens	1,151	0,0087
Número de mulheres	1,028	0,9007
Número de familiares	0,860	0,3065
Número de externos à família	1,175	0,0032

Modelos Bivariados	Razão de Possibilidades (odd ratio)	p
Discussão interpessoal em saúde		
Número de indivíduos	1,088	0,2597
Número de homens	1,059	0,5238
Número de mulheres	1,141	0,3060
Número de familiares	0,813	0,0253
Número de externos à família	1,355	0,0008

Fonte: Elaboração própria (dados de pesquisa de campo).

Nenhum dos meios de comunicação formais, usados para obter informações sobre agricultura, esteve associado à percepção dos participantes sobre os benefícios ou prejuízos na adoção da Tisi. Já o uso de jornais e outras fontes de informação sobre o tema da saúde estiveram associados significativamente com a percepção de benefícios em utilizar a prática. O número de indivíduos, de homens e de pessoas externas à família com quem os participantes discutem o tema da agricultura esteve associado positivamente com a percepção de benefícios da Tisi. Quanto maior o número de membros externos à família com quem se conversa sobre saúde, maior a probabilidade de o agricultor considerar que a Tisi traz vantagens para o cultivo do arroz. Pelo contrário, os participantes que conversam com membros da família sobre o tema da saúde têm uma probabilidade menor de considerar que o uso da Tisi traz preferencialmente benefícios para o cultivo do arroz.

4 DISCUSSÃO

Os resultados deste artigo demonstram que os produtores reconhecem as interações entre os aspectos econômicos, ambientais e de saúde da Tisi, mas consideram prioritariamente os aspectos econômicos do processo produtivo na hora de avaliarem os benefícios e prejuízos potencialmente trazidos pela adoção da técnica. Entre as características da Tisi consideradas mais benéficas (controle de pragas, redução de agroquímicos, produtividade e renda familiar), as duas primeiras têm implicações nos aspectos ambientais, de melhoria do controle de pragas e da saúde humana, pelo manejo mais efetivo de agroquímicos. As duas últimas características mais benéficas abordam aspectos essencialmente econômicos, como o aumento da produção e da renda familiar. Porém, os benefícios econômicos da Tisi ganham relevância, já que tanto a ocorrência de pragas quanto o uso de agroquímicos interferem nos custos da produção. No mesmo sentido, os produtores que declararam ter despesas com a compra de fertilizantes, pesticidas e com a contratação de mão de obra, também consideraram que a Tisi traz predominantemente vantagens. Especialmente entre esses produtores, é provável que a implementação da prática, que reduz as despesas com a produção, seja prontamente percebida como vantajosa, conforme apontado em estudos anteriores (MUBEEN; JABRAN, 2019).

Os dois aspectos da Tisi considerados mais prejudiciais para a produção de arroz também têm implicações econômicas para o produtor. A irrigação dos campos de cultivo tem um papel direto no controle de ervas daninhas nos campos de arroz, que proliferam sem a camada permanente de água (ISHFAQ *et al*., 2020). Assim, a mudança no regime de uso intensivo de água para um cultivo mais aeróbico pode significar um aumento dos custos de produção, pela compra e aplicação de herbicidas, mas principalmente pela contratação de mão de obra adicional, que foi o segundo aspecto da Tisi considerado mais prejudicial para a produção de arroz.

Os resultados deste estudo demonstraram que algumas características sociodemográficas estiveram associadas à percepção de benefícios na aplicação da Tisi. Os participantes do estudo mais experientes na agricultura percebem mais benefícios no uso da Tisi do que os produtores que estão há mais tempo trabalhando no cultivo do arroz. Esse resultado é compatível com outros estudos que mostraram que a experiência agrícola implica em conhecimentos adquiridos ao longo do tempo e são importantes na avaliação de inovações tecnológicas (LEBLANC *et al*., 2020).

Apesar do conhecimento sobre a malária estar associado positivamente a uma percepção mais favorável sobre a Tisi, mais de 70% dos produtores não identificaram o combate à doença como um benefício explicitamente associado à sua adoção nos cultivos de arroz. Esse resultado sugere que a maioria dos produtores possui pouco conhecimento sobre o ciclo reprodutivo dos mosquitos vetores e sobre o papel da Tisi na interrupção desse ciclo. Além disso, as próprias observações e experiências práticas dos produtores com a Tisi, seja nos seus cultivos, nos lotes dos vizinhos ou em unidades demonstrativas, podem dificultar a compreensão dos efeitos da técnica para redução do risco de transmissão da malária. Três fatores podem contribuir para essas dificuldades: i) quando a Tisi é aplicada isoladamente em uma área pequena, ela pode não ser efetiva em reduzir significativamente as populações de mosquitos adultos, especialmente quando os produtores vizinhos seguem mantendo seus campos permanentemente inundados; ii) por mais que os curtos períodos sem água nos cultivos sejam suficientes para eliminar as larvas dos mosquitos, a eficiência da técnica no combate à malária depende da duração dos períodos inundados, que, em casos de descuido ou desinformação do produtor, podem viabilizar o fechamento do ciclo larval sempre que ultrapassarem oito dias; e iii) durante cada fase de inundação dos campos de arroz, mesmo aquelas com duração menor a oito dias, os produtores observam a proliferação de larvas de mosquitos, gerando dúvidas sobre a eficácia da técnica.

Conjuntamente, esses resultados sugerem que campanhas de informação sobre a malária não devem se limitar ao campo da saúde, e sim reforçar explicitamente os vínculos que existem entre uma prática agrícola de controle rigoroso da água e seus efeitos diretos na redução de doenças vetoriais.

Os resultados revelaram aspectos importantes sobre o papel dos canais de comunicação nos temas de agricultura e saúde entre os agricultores do vale. A percepção de benefícios no uso da Tisi não esteve associada ao uso de nenhuma das mídias de massa como fontes de informação sobre agricultura. Pesquisas anteriores revelam a importância de campanhas de comunicação para promover práticas sustentáveis em agricultura e saúde (MERTENS *et al*., 2017). No entanto, esse resultado sugere que os canais de comunicação formais não têm sido aproveitados para divulgação de informações sobre as vantagens da Tisi para a atividade produtiva.

Por outro lado, os resultados mostram que existe uma discussão interpessoal ativa sobre agricultura entre os participantes do estudo e sugerem que as informações sobre os benefícios da Tisi podem circular entre os agricultores do sexo masculino que conversam sobre o tema. Além disso, os homens conversam sobre agricultura de forma mais frequente com pessoas externas à família do que com os seus familiares. Em geral, essas discussões estão associadas a uma percepção de benefícios no uso da Tisi, indicando que a comunicação interpessoal com vizinhos, amigos e técnicos agrícolas, que prestam assessoria periódica aos agricultores, tem potencial de ampliar o processo de difusão de informações que podem favorecer a adoção da técnica. Finalmente, a participação dos produtores nas entidades de gestão coletiva da água do vale também esteve associada a percepções mais favoráveis sobre a Tisi. Essas entidades são espaços coletivos de encontros e eventos que favorecem a circulação de informações sobre inovações agrícolas e uma melhor compreensão sobre os benefícios de uma nova prática (HUAMANCHUMO *et al.*, 2008).

Jornais, revistas e livros de saúde acessados em centros de saúde, farmácias e igrejas parecem representar meios de difusão de informações favoráveis ao uso da Tisi e podem ser aproveitados para difundir conhecimentos sobre saúde que se refletem nos modos de produção agrícola da região. A associação entre a percepção de benefícios da Tisi e a discussão sobre a saúde com membros externos à família reforça a ideia de que as informações sobre a saúde compatíveis com o uso da Tisi podem ter circulado na ocasião de consultas médicas ou em visitas aos postos de saúde. As razões pelas quais as conversas sobre o tema da saúde com membros da própria família estão associadas a uma maior percepção de prejuízos no uso da Tisi merecem ser investigadas.

5 CONCLUSÃO

O conjunto de resultados mostra a relevância de integrar uma análise mais detalhada sobre as percepções dos agricultores em relação aos impactos ambientais, sociais e de saúde da Tisi e a caracterização dos fatores associados a uma percepção favorável quanto ao seu uso nos campos de arroz. Essa análise integrada permite compreender os aspectos considerados mais relevantes pelos produtores, com potencial tanto de facilitar quanto de frear o processo de adoção, e como as interações entre esses fatores formam as percepções que guiam a tomada de decisão.

O estudo mostrou que os produtores priorizam tanto as implicações diretas e puramente econômicas quanto suas implicações econômicas indiretas, que têm foco nos aspectos ambientais e de saúde humana. Desenvolver novas ações de promoção da Tisi que vinculem as questões ambientais e de saúde com as prioridades econômicas dos produtores, para que sejam capitalizadas pelas redes, canais e espaços de comunicação privilegiados de debate sobre os temas da agricultura e da saúde, aparece como uma estratégia promissora para contribuir para a sustentabilidade da produção de arroz no Vale do Jequetepeque.

As informações geradas neste trabalho contribuem para o conhecimento sobre as estratégias de promoção de práticas agrícolas de economia de água, que refletem em ganhos econômicos e permitem reduzir a vulnerabilidade socioambiental e de saúde das populações. Podem ainda ser aproveitadas por novas pesquisas tanto no Vale do Jequetepeque quanto em diferentes regiões que apresentem desafios epidemiológicos semelhantes, em contextos de escassez de água, de mudanças ambientais e incertezas climáticas.

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Role of water infrastructure programs for family farmers in strengthening adaptive capacities to climate change: lessons from the Cisterns Program in Semi-arid Brazil

Papel dos programas de infraestrutura hídrica para agricultores familiares no fortalecimento das capacidades adaptativas às mudanças climáticas: lições do Programa Cisternas no Semiárido Brasileiro

Patrícia S. Mesquita [1]

Louise Cavalcante [2]

[1] *Phd in Sustainable Development, Post-Doctoral Researcher, Project INCT-Odisseia, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília, Brazil*
E-mail: patriciasmesquita@gmail.com

[2] *Masters in Sustainable Development, Phd Student in Public Administration and Policy – Wageningen University, Wageningen, NL, and Associate Researcher at the Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brazil*
E-mail: louise.cavalcantedesouzacabral@wur.nl

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ABSTRACT

The semi-arid region of Brazil, marked by low human development indicators, has historically suffered from water scarcity, being the focus of public policies to reduce socioeconomic, water, and climatic vulnerabilities for more than a century. Among the recent initiatives, the Cisterns Program stands out as an attempt to guarantee water and food security for family farmers through the construction of social technologies for water storage, such as cisterns production. Thus, the research objective was to analyse the perception of farmers and institutional actors involved with the Program about the impact of the 2011-2018 drought on the functioning of cisterns and to discuss how water infrastructure programs can improve the adaptive capacity of farmers affected by climate change. Through semi-structured interviews with institutional actors at the regional/national level and with farmers in semi-arid Brazil in the years of 2017/2018, the results indicate that access to the social technology seems to strengthen the relationship between water and food security, and the specific capacity of farmers in dealing with climatic risks. We conclude with lessons and recommendations from the Brazilian experience that can be useful for actors from other semi-arid regions involved in water infrastructure programs.

Keywords: Brazilian semi-arid. Drought. Water. Cisterns. Climate change. Adaptation.

RESUMO

A região semiárida do Brasil, uma região marcada por baixos indicadores de desenvolvimento humano, tem sofrido historicamente com a escassez de água, sendo há mais de um século o foco das políticas públicas para reduzir as vulnerabilidades socioeconômicas, hídricas e climáticas. O Programa de Cisternas se destaca como uma tentativa de garantir a segurança hídrica e alimentar dos agricultores familiares por meio da construção de tecnologias sociais de armazenamento de água, como a cisterna de produção. O objetivo da pesquisa foi analisar a percepção dos agricultores e atores institucionais envolvidos com o Programa sobre o impacto da seca de 2011-2018 no funcionamento das cisternas e discutir como os programas de infraestrutura hídrica podem melhorar a capacidade de adaptação dos agricultores afetados pela mudança climática. Por meio de entrevistas semiestruturadas com atores institucionais em nível regional/nacional e com agricultores do semiárido nos anos 2017/2018, os resultados indicaram que o acesso à tecnologia social parece fortalecer a relação entre a segurança hídrica e alimentar, e a capacidade específica dos agricultores em lidar com os riscos climáticos. Concluímos com lições e recomendações da experiência brasileira que podem ser úteis para atores de outras regiões semiáridas do mundo envolvidos com programas de infraestrutura hídrica.

Palavras-chave: Semiárido brasileiro. Seca. Água. Cisternas. Mudanças climáticas. Adaptação..

1 INTRODUCTION

The search for water and food security is an ever-present theme in the discussion of public policies aimed at Brazilian rural areas, especially in the Semi-arid. The region, which occupies 940,000 km² in nine states, with 27,870,241 inhabitants (MINISTÉRIO DA INTEGRAÇÃO NACIONAL, 2017), is a place where policies aimed at reducing socioeconomic vulnerabilities have a considerable weight in the local historical trajectory, marked by water scarcity and the lowest socioeconomic status Indicators of the country. In 2010, the Human Development Index of the Brazilian Semi-arid municipalities was at the lower limit for "medium" (0.59), far from the national average of "high", but significantly better compared to the "very low" index during the year of 1991 (PNUD; IPEA; FJP, 2016).

In this region, socioeconomic improvements were sought for many years through the "fight against drought" strategy, constructing public/private reservoirs and irrigation projects. Since the first public dam in 1906, the federal government1 has built hundreds of large ones distributed without concern for their effectiveness and impact on the development of family agriculture (MAGALHÃES, 1993). In the post-war era, starting in 1945, the government began to address the drought problem within a regional development strategy (BURSZTYN, 1984), with new institutions linked to hydroelectric power generation, irrigation projects, and bank finance economic activities. Such initiatives aimed to ensure that populations, especially the most vulnerable, had access to water to drink and produce food, not dying of hunger, as observed on several occasions in the past. The Great Drought of 1877/1879 was one of the most impactful in the history of Brazil, causing a great exodus and the death of 500,000 people, more than half of the population of the state of Ceará at the time (GREENFIELD, 2001; SMITH, 1879). Concomitantly with water-related strategies, other approaches focused on alleviating hunger during droughts by delivering emergency baskets, exchanging food for work, and forcing emigration to other states, aiming, in addition to feeding populations, at controlling looting of government food stores. In Ceará, concentration camps for migrants were created in 1932 to imprison the poor and keep them out of the city of the wealthy (RIOS, 2014). In general, until the 1980s, policies of an emergency nature existed to combat drought, without concern about the human right to water and food.

From the 2000s onwards, there was a significant change in the region, when the implementation of a national and integrated policy proposal around the reduction of poverty and food insecurity began through the Zero Hunger Program (2003). The various initiatives associated with the Program have improved access to productive and non-productive resources, income, productive capacity, food and nutrition security, access to other public programs, among other positive impacts. Concerning abundant

resources, the increase in the means of production has been identified as the critical factor that enables the increase, expansion, and diversification of production for self-consumption (MELLO *et al.,* 2014; MESQUITA *et al.,* 2020). Income transfer through the Family Allowance Program (Bolsa Família) reduced food insecurity in high social and climatic vulnerability (PALMEIRA; SALLES-COSTA; PÉREZ-ESCAMILLA, 2020). However, after 2016 these multidimensional impacts of the initiatives showed a reversal in the face of the country's political and economic scenario (SOUSA *et al.,* 2019), worsening even more in the face of the Covid-19 pandemic (CARVALHO; VIOLA; SPERANDIO, 2021; RIBEIRO-SILVA *et al.,* 2020). In addition to the impacts on health, the pandemic has created several impediments to production and commercialisation by small Brazilian family farmers, increasing poverty and food insecurity, especially in more vulnerable regions such as the Semi-Arid (RIBEIRO-SILVA *et al.,* 2020).

In addition to the region recognisedgnized as a climate hotspot (MARENGO *et al.,* 2020; SIMÕES *et al.,* 2010), there is another challenge of adapting to climate change. According to the IPCC Fifth Report (2014), the average annual temperature increase in the Northeast region should be between 2.0°C (RCP scenario 2.6) and 5.0°C (RCP scenario 8.5) by 2100 (IPCC, 2014). Such a scenario highlights the need for greater attention to policies with proven positive impacts in the region. Those are mainly built upon the "coexistence with semi-arid" paradigm and have been related to climate adaptation (LINDOSO *et al.,* 2018; MESQUITA *et al.,* 2020; MILHORANCE *et al.,* 2020). In this context, the Cisterns Program stands out for being based on the construction of social technologies for access to water, with several impacts on the food and water security of beneficiaries (CAVALCANTE; MESQUITA; RODRIGUES-FILHO, 2020; FERREIRA *et al.,* 2015; VIRGENS *et al.,* 2013), and with the potential to promote changes linked to climate adaptation. Moreover, the Program is a model of how family farming innovations can be transformed into public policy. Through the action of civil society and its dissemination, it reached the level of a national strategy (ARSKY, 2020; MACHADO; ROVERE, 2017; NOGUEIRA, 2017).

Based on the relevance of the Cisterns Program in the themes above and on the region's status as a climate hotspot, this research discusses the perception of beneficiaries and institutional actors about climate change, the impacts of the 2011-2018 drought on the Program's functioning, and its importance in the face of climate change. The two types of adaptive capacities proposed by Eakin *et al.* (2014) are used for analysis, with generic capacity defined as the assets and capabilities that build the capacity of different systems to face and respond to a variety of stressors, that is, the ability to respond socially, economically and politically, such as income, access to education, health, social capital, physical assets, etc.; and the specific capacity, the ability to anticipate, respond and identify a particular (climatic) risk, developed through the use of climatological information, species resistant to the climate, irrigation, and other practices. Next, the methodological path and the implementation process of the Cisterns Program are presented; followed by the data on the perception of respondents regarding the impact of climate on the Program and the relevance of cisterns; finally, the impact of water infrastructure programs on water and food security is discussed, especially in the context of climate change, and recommendations for water infrastructure programs in semi-arid regions around the world are provided.

2 METHODOLOGY

The research was developed in two stages to fill the various areas in which implementing the Cisterns Program develops and materialises. First, beneficiaries and local actors involved with the Program were interviewed in three Brazilian states. In October/2017, 23 farmers were visited in the sub-medium São Francisco river region (Figure 1), in the states of Pernambuco (16 around the municipality of Petrolina) and Bahia (7 in the Paulo Afonso and Juazeiro municipalities); in September/2018, 16 beneficiaries were visited in the state of Ceará (Itapipoca, Santa Quitéria, Itatira, and Quixeramobim), totalling 39 interviewed farmers. On these occasions, when possible, interviews were conducted with local and technical coordinators (10 respondents). Due to the gradual learning about the Program, some additional questions, such as those related to climate, were added in the second fieldwork (Ceará).

Subsequently, in November/2018, to complement the collected information, face-to-face and remote interviews were conducted with the management teams of the partner institutions involved in the implementation (5 respondents) and with the federal government team responsible for the Program (former Ministry of Social Development – SESAN/MDS – 5 interviewees).

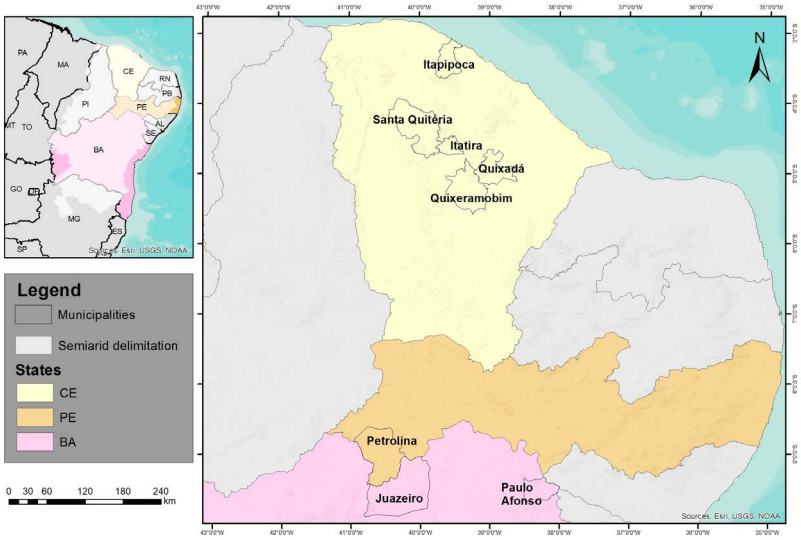

Figure 1 | Study area

Source: The authors

All interviews were qualitative, semi-structured, with sample size determined by data saturation and time available in the field. Data saturation was reached when the research team observed a repeated pattern of responses. According to the data extracted from the statements, those were tabulated and quantified in the case of beneficiaries' data. Due to the limited sample size, percentages are presented only to facilitate the qualitative debate and provide a general context. In general, the research consisted of asking rainfed farmers, technicians, and institutional actors about 1) how the extensive drought-impacted production and the Cistern Program; and 2) the relevance of the water technology in the face of climate change. Additionally, the Research Ethics Committee in Human and Social Sciences at the University of Brasília (UnB) assessed and approved the research project and its planned execution process.

2.1 CISTERNS PROGRAM

The Cisterns Program[2] has been responsible over the years for expanding the 1st and 2nd water cisterns widely throughout Brazil (COSTA; DIAS, 2013). The 1st, known as the consumption cistern, aims to improve access to water for human ingesting, while the 2nd water, the production cistern, aims to support small-scale productive activities. Both social technologies were created with the ultimate goal of helping farmers and other vulnerable populations to achieve food and nutritional security through access to water in quantity and quality suitable for family consumption (e.g., cooking and drinking) and enough water to maintain subsistence farming activities in the backyard or the field.

Briefly, the process for implementing the production cisterns involves four main steps: 1) social mobilisation – includes the process of choosing communities/families, and is the responsibility of the executing entity hired by the ministry. It occurs in partnership with a commission formed by representatives of the municipal secretaries related to health, education, food security, agriculture, and civil society (as members of councils and community leaders). Territorial/regional meetings occur to discuss the project and plan the development of actions; 2) select beneficiary families – based on a guiding list sent by the Ministry, obtained from the Federal Government's Single Registry for Social Programs. With the list of

possible families to be included in the Program, the executing entity presents the project to the local commission, intending to guarantee legality and social control, and the field technicians validate family information in the field; 3) registration of families – occurs in an individual or collective meeting (with the community), where beneficiaries are invited to participate in the training. On this occasion is made the collection of extra information for registration in the SIG Cisternas (the program information system); 4) training of families – occurs through two courses: Water Management for Food Production (Gapa) and the Simplified Water for Production System (Sisma). Here, the items delivered in the productive kits are also defined to promote food production, such as seeds, seedlings, and others (SESAN, 2017). Finally, the construction of cisterns occurs with the involvement of beneficiaries, who offer the counterpart of work for the construction of the technology, mobilising members of the family or community in a joint effort scheme, and/or contracting professionals.

3 RESULTS

3.1 RESEARCH DESIGN

Perceptions about climate change were investigated only in the Ceará fieldwork (N = 16), where 88% of respondents mentioned perceiving changes in the climate over the years. Even when asked about the climate in the last 15-20 years, it was noted that the time frame of interviews varied from 10 - 20 years (33%), 2 - 10 years (27%), 2 years (13%), and finally, 40 years ago (7%).

Regarding the type of changes, 60% mentioned temperature was modified, hotter for 78% of beneficiaries and less desirable for 13%. Regarding rainfall, 93% noticed changes, among which 14% described increased rainfall, while 86% described decreased rainfall (Table 1). Precipitation has been more widely spaced, less intense, delayed, or unevenly distributed. Some comments on the perception of climate change were: “it is hotter ...”, “rain is weaker, and it is hotter…”, “winters were better…” and still, “every year it rained in the winter when I was young ... now it stays longer without rain and hotter ...”. And, finally, “20 years ago there was no lack of winter ... it changed a lot, the heat was normal, it wasn’t so hot… it was 6 years without raining ... it seems that the sun has turned on…”.

Table 1 | Perception about climate

*Climate (N = 16) **			*Temperature (N_climate = 15)*		
	N (N%)		N (N%)		N_changed_Temp. (N%)
Has changed	14 (88%)	Has changed	9 (60%)	Hotter	7 (78%)
Always the same	1 (6%)	Always the same	0	Less hot	2 (22%)
NS / NR	1 (6%)	NS / NR	6 (40%)		
			Precipitation (N_climate = 15)		
			N (N%)		N_changed_Precipitation (N%)
		Has changed	14 (93%)	More	2 (14%)
		Always the same	0	Less *	12 (86%)
		NS / NR	1 (7%)		

** Spaced rains (N = 2), less intensity (1), Uneven distribution (1), late (5) and NA (3).*
Source: Authors.

When asked about what happened to production in extreme periods – heavy rain in a short period of prolonged drought – answers varied and did not follow a pattern. The perceptions were specific to each breeding and crop type and depended on location (Table 2).

Table 2 | Impacts of extreme droughts and rains

Droughts	*Rain*
Crops	
Loss of all yard;	Weak plants (excessive rain when flowering);
Partial loss of production;	Lower quality production (ex: yellow beans);
Dryness to production;	Loss of beans;
Burnt plants;	Loss of corn;
Loss of creole seeds;	
Animals	
Death of animals;	Wet and cold animals (chicken, sheep);
Slimming of animals;	Diseases – e.g., soft hooves;
Loss due to increased consumption;	Animal suffering (cold);
Animal suffering (heat);	
Illnesses;	
Behaviour change – hide animals due to the heat/ sun;	

In general, farmers emphasised that during the dry season, it was challenging to produce or keep producing: "the heat disturbs… even watering [the plants] it burns because it is very hot… animals are under the trees, they are hiding. ... ". In the rainy season, the soil became muddy, becoming hard to produce: "if it rains a lot, beans are no good ... corn prefers dry weather ... but it is better when it is raining more...". Regarding animals, impacts were different depending on the animal: "[when the soil is swamped] plants cannot take it ... goat and chicken do not do well in the rain, pigs are ok...". Finally, another observed: "I don't like the sun, animals suffer ... chickens keep trying to get inside the house...".

According to most technicians and coordinators involved in the implementation, the climate impacted the Cisterns Program. However, one of the interviewed actors pointed out that climate change does not exist and would be a natural phenomenon without connection with short or long drought periods. Among the coordinators who belong to the leading group that believes that the climate changes impacted the Program, it was mentioned that the seven years of drought made it difficult mainly because farmers could not immediately see the results of the implemented technology. Many felt discouraged and ended up not investing in the plantation or animals. Another interviewee recalled that although the Program targets places that generally have eight months without precipitation, the last drought period stood out, as it was related to one of the worst droughts in the previous 50 years.

The rainy season would also have impacted the implementation of the Program in many different ways. During the winter (how the rainy season is named), heavy rains made it difficult to access beneficiary areas and build cisterns due to holes and muddy roads, which at times became insurmountable. Because of this, there were cases of stoppage in the delivery of materials and visits to avoid material and service losses. One of the interviewees noted the difficulty in selecting beneficiaries during the rainy season - "... we just had rains and dams are full... then they think the cistern won't be necessary". This perception of a momentary improvement in climate, together with extra costs for families regarding food and lodging for bricklayers, could be inhibiting the decision to participate in the Program. In the dry season, besides the mentioned impacts on beneficiaries, the difficulty accessing water for construction (9,000 litres required) and for the partial filling of cisterns (dead volume – so avoids cracking with the thermal variation was reported. Still, the exclusion of certain animals, such as pigs, from the production kit – due to the high water consumption and lack of forage from producers (loss of crop in the previous year); and the loss of seeds and seedlings by suppliers and beneficiaries. Moreover, Program implementation

could be enhanced if it avoided overlapping with the agricultural calendar. Some beneficiaries stopped participating in training activities (or sending third parties from the family) due to productive activities.

The Program's managers' opinions about climate were aligned with the previous results. The semi-arid region had less water availability, generally attributed to climate change and local anthropogenic changes, such as deforestation and desertification. In this sense, climate change could affect the Program in several ways. As the size of social technologies is based on the amount of water necessary for families' consumption and annual climate patterns, changes in water availability and its distribution may generate negative impacts. For example, the 16,000 litres of consumption cisterns was calculated to fill a house with a 40 m² roof, which, with less rainfall, may no longer be filled as planned. There may also be a need for different types of technology, a change in the same size, or even a need to expand the area of operation and priority audiences. In addition, the team mentioned beneficiaries' frustration. At the same time, technologies were being constructed during the prolonged drought, as farmers were unable to fill cisterns with water and strengthen their coexistence with the Semi-arid. Within the rationale of families, 2nd water cisterns would often be only for domestic consumption in the dry season – the logic would be to use all other available sources until they are exhausted, and then this cistern for non-productive purposes. Finally, it was reported that climate extremes sometimes hampered the Ministry's inspection calendar, but notably by torrential rains.

3.2 RELEVANCE OF THE CISTERNS PROGRAM IN THE FACE OF CLIMATE CHANGE

Interviewed farmers believe that cisterns can help people stay in the countryside, allowing them to coexist with the semi-arid region and extreme weather events (67%). Of these, 50% reported that water technologies, such as the cisterns, increase the possibility of staying in the countryside ("It is a pity to leave the little things that served us and abandon ..." and "it is already a huge help ... it is an incentive"). Another 19% said that the Program assists due to production aid, while 15% said it made it possible to store water. Still, related to the coexistence with the semi-arid, 26% said that cisterns would only help under the right circumstances, for example, "... if you dare to work", "if you have the motivation to work". One interview participant noted, "Many people do not want [it]... those who want [it] to, fight for it ...".

According to technicians, families were becoming more prepared to live the prolonged periods of drought, having better conditions to face climatic challenges due to the water infrastructure. One of the interviewees pointed out that the implementation of cisterns is an adaptation action due to the concepts and actions addressed in the perspective of coexisting with the semi-arid region. It is also a Program that influences mitigation: "it also has the prospect of restoring [vegetation], [which generates] increases in CO_2 sequestration". During the emergency that many municipalities were subjected to, the Program could also prevent rural exodus since it created labour opportunities for bricklayers and others willing to work.

On the part of managers, it was mentioned that for some farmers, the Program would be more of a water reservoir for moments of water scarcity (water from multiple sources besides appreciation), being more for the process of climate adaptation than for the production or insertion in markets. For the Ministry, cisterns have a very close relationship with the issue of climate change, although this plan was only recently included in the planning and debate of the Program. Through this social technology, farmers can better deal with droughts without depending on the "drought industry" (e.g., distribution of water in exchange for votes – (BURSZTYN, 1984), the initiative has even been awarded a prize as a global strategy to combat desertification and land degradation, with impacts related to climatic change (Future Policy Award). From the moment families receive the social technology, they have the possibility and the option to create a different microclimate on the property, with long-term impacts on their production.

These interviewees highlighted that the impacts of 2nd water cisterns on domestic water management in times of drought showed that it is essential to expand the water potential of families, with underground

dams, trench barriers, and other small infrastructures, since many families with cistern managed not returning to extreme situations due to the drought.

Given this perspective, the Program's focus, which previously was in the area of food security and water security, would now be migrating to climate change due to the National Policy for Adaptation to Climate Change (Law No. 12,187/2009) and also due to the need of opening new funding opportunities (especially for production cisterns that has a lower priority and budget, when compared to the 1st water). In other biomes in Brazil, this would also be of great importance in the context of climate change. In the Amazon, for example, cisterns would be seen as a way of enabling livelihoods with health and sanitation, with treated water serving for the hygiene of products produced, consumed, and traded, access to sanitary structures (bathrooms), and potentially more significant conservation of the environment.

4 DISCUSSION

The 2nd Water Cisterns Program was created to promote access to water for food production through the implementation of low-cost and straightforward social technologies. This modality of the Program was aimed at increasing the water availability of family farmers so that they produce food, either for self-consumption or for the sale of surpluses, guaranteeing, in addition to water security, food security. In these aspects, some studies indicate that the Program has contributed to what it was created for (CAVALCANTE; MESQUITA; RODRIGUES-FILHO, 2020; FERREIRA *et al.,* 2015; VIRGENS *et al.,* 2013). In general, research indicates that farmers have increased the use of agroecological production methods, some because they already had the knowledge passed down between generations, and others because they learned in the training that is part of the implementation stages of the Program (FERREIRA *et al.,* 2015). There is an indication that in the state of Pernambuco, the Program has been constituted as an essential tool for improving food security and strengthening the identity bonds of families (FERREIRA *et al.,* 2015). The production of fruits, through the water of production cisterns, also helps in meeting the daily nutritional needs of families, especially those of vitamin C (ARAÚJO; BRITO; CAVALCANTI, 2011). Furthermore, Cavalcante *et al.* (2020) point to positive impacts on food security and the ability to adapt through social learning, as beneficiaries described greater confidence in their knowledge and skills as a result of courses, in addition to contentment due to the storage of water and increases in production and sales of the surplus. The effects of the Program's implementation methodology are also highlighted by Arsky (2020), who discusses the role of "experimenting farmers", producers who started to exchange experiences and shared knowledge with other farmers.

Due to the multiple impacts, the Cisterns Program, in general, was seen as an adaptation project by all beneficiaries, coordinators, and technicians interviewed here, as it helps farmers to live with more quality in prolonged periods of drought. It was also considered an essential factor for people persisting in rural areas. However, the various positive impacts can be compromised due to increased drought periods, especially climate change. As mentioned, most of the problems in the Brazilian semi-arid region stem from the lack of water, and climate change will contribute to worsening this situation. Recent studies indicate that the last multi-annual drought period 2012-2017 was the longest in the previous 50 years (BRITO *et al.,* 2018; MARENGO *et al.,* 2020; MARENGO; CUNHA; ALVES, 2016). This came to impact the performance of agricultural activities (SANTANA; SANTOS, 2020) and the water supply for priority uses (LIMA; MAGALHÃES, 2018). This context of water scarcity led to several impacts on the Cisterns Program, as can be seen in the results. Other programs in Brazil and around the world have also been impacted by the climate, such as the Food Acquisition Program (MESQUITA; BURSZTYN, 2017), the National Program for Strengthening Family Agriculture (Pronaf) (LIMA; MAGALHÃES, 2018), and the Millennium Villages, a school meal program in Ethiopia (REMANS *et al.,* 2010).

Farmers also reported a perception of climate change, with almost all respondents mentioning that climate had changed somehow. For them, increases in temperature and precipitation regime changes

were noticeable, with the concentration of rainfall periods (with a significant time spacing between events) and less frequent rainfall being often highlighted.

These have led to various reactive adaptation strategies, such as creating ways of protecting animals and changing planting times, many of which are traditional handling techniques practised by farmers from other countries worldwide. For example, in an arid zone of Myanmar, it was observed that, given the impediments to production caused by climate changes, farmers were strengthening and reviving the use of conventional water management practices, such as rainwater collection and similar (SWE *et al.,* 2015). As noted by Mesquita *et al.* (2020), ex-post strategies, adjustments implemented after climatic shocks and more focused on facing its impacts (ABID *et al.,* 2020; IPCC *et al.,* 2001; SHIFERAW *et al.,* 2014) are mainly used in the face of climatic adversities in Semi-arid Brazil, although ex-ante (before the shocks) adaptation is more advantageous since avoids possible assets and resources losses, and even irreversible damage of farmers' capital related to continuous losses (HANSEN *et al.,* 2004; MESQUITA; MILHORANCE, 2019).

As mentioned, climate can also sometimes influence farmers' decisions to accept participation in the Program. Thus, we underline there is not only an impact of droughts in water infrastructure programs due to climate change, but also of torrential rains, and both scenarios should be considered when discussing the inclusion of beneficiaries, the implementation processes, the execution schedule, and the scenario of the water-related programs within a climate change context. It is worth mentioning that actions that count with the participation of beneficiaries must consider the agricultural calendar and the unavailability of farmers in the initial period of rains and planting. Finally, it is worth stating the importance of another role assigned to the Program – of occupying the local workforce, subject to an exodus, in a context of climatic emergency. From 2013 to 2016, 48 million people were affected by droughts in Brazil, 6 times more than floods. 4,824 drought events associated with human damage were quantified, almost 3 times more than flood events (1,738). 2016 was the most critical year in drought impacts on the population (ANA, 2017). Historically, several programs have used this rationale of allowing workers during drought times in Semi-arid Brazil. Still, one must realise the differences between the past and present models and the role that cisterns could play during these times. The work carried out by farmers represents an investment in family capital, with the prospect of helping to maintain producers in rural areas over the generations; it provides a personal, non-transferable, and non-communal asset, unlike the historical construction of dams and roads carried out by work fronts in the significant droughts.

4.1 CISTERNS STRENGTHENING THE RELATIONSHIP BETWEEN WATER AND FOOD SECURITY AND GENERIC AND SPECIFIC CAPACITIES

Social technologies for water access are symbolic in discussing the importance of social programs for farmers facing extreme drought, thus guaranteeing some water security and food and nutritional security. Even if cisterns and other technologies are not filled with rainwater, these nevertheless represent a structure that helps to face difficulties related to water scarcity, as they can be supplied with water trucks purchased with their income (since only the consumption cistern is provided by a government water truck program – Operação Carro-Pipa), with piped water, or drawn from wells, weirs, and other sources.

In this regard, the Cisterns Program can be seen as a connection of the water-food nexus, since that at the same time that allows greater water security; it also seeks to increase the productive capacity and food security of farmers. This concept is based on the inseparability between water and food, and from the rationale that any changes in water quality and availability affect (and are affected by) production systems, that is, there are several interdependencies, synergies, and trade-offs between the two, in addition to the various interconnections with climate, energy, access to land, among other factors (BREARS, 2015; LAIO; RULLI; SUWEIS, 2017).

Still, several aspects have to be observed when defending such an argument since factors other than access to water are linked to productive capacity and even to food security as a whole. In this relationship, access to extension and education services can exert some influence. For example, the lack of adequate water management, together with the lack of technical assistance, sometimes leads to the erroneous feeding of animals and their lower productivity (BURNEY *et al.,* 2014). Through rural extension or education, the importance of access to knowledge has already been highlighted for the success of initiatives such as the Cisterns Program (CAVALCANTE; MESQUITA; RODRIGUES-FILHO, 2020). Mesquita *et al.* (2021) highlighted that technical assistance and rural extension technicians (Ater, in the Brazilian acronym) have the role of street-level bureaucrats (LIPSKY, 2010) since their activity directly affects how programs, such as the Cisterns, are implemented at the local level. The Program, when implemented locally by an executor who aims for agroecological production, also contributes to the recovery and preservation of the Caatinga Biome, strengthening the relationships between the human-nature system, and mitigating climate change, even if in a limited way, as it inhibits deforestation in the Biome. The role of technicians is crucial for disseminating agricultural techniques and climate information for better adaptation to climate change in other arid and semi-arid locations around the world (SWE *et al.,* 2015).

From the perspective of climate change, the Program seems to be able to minimise the extreme and unwanted responses of farmers in drought events, such as abandonment of areas, migrations, among others, since food insecurity (MILAN; RUANO, 2014), and socioeconomic and educational level are related to this behaviour (DELAZERI; DA CUNHA; OLIVEIRA, 2021). The Program, by strengthening income growth and access to technical knowledge, can influence the family's decision to emigrate or not in the face of shocks.

Although the cisterns influence more in specific capacity-building, beneficiaries are also participants in the Family Allowance Program, an initiative that deals with generic capacities and structural deficits related to climate vulnerability. In 2010, this program aided around 54.3% of the population in the Brazilian Semi-arid region (SILVA; PAES, 2019). For Brazilian semi-arid, specific capacities were defined as

> manifestations of the ability to respond to and manage an identified climate hazard (e.g., drought emergency response plans, hurricane warning systems, climate forecasting, design and construction of protective infrastructures such as irrigation and public works such as reservoirs (LEMOS *et al.,* 2016a, p. 171).

In this study, using food insecurity as a proxy for vulnerability to climate change, two risk management strategies were identified as most relevant – the Crop Guarantee Program (Seguro Safra), insurance against crop failure, and access to irrigation, both important in modulating food insecurity. For the latter strategy, an association between high levels of generic capacity and this specific capacity was observed, suggesting that the most significant vulnerability reduction results are found when farmers invest additional income in strengthening specific capacity (irrigation). According to Eakin *et al.* (2014) and Lemos *et al.* (2016b), even if there is a particular capacity, a minimum level of generic capacity is necessary to manage risks. In this sense, it is worth emphasising the relevance of the researched Program in the construction of sustainable irrigated production systems with water from the cisterns (GONÇALVES; RIOS; CARVALHO, 2013). Obermaier *et al.* (2009) emphasise that sustainable irrigation techniques are essential to improve adaptive capacity in semi-arid areas of Brazil.

However, one should also think of the limited role of large-scale irrigation as a strategy to strengthen specific capacity (HERWEHE; SCOTT, 2018) to be promoted in an environment that suffers from increasingly extreme droughts, especially when thinking about the implementation of a broad irrigation strategy for the semi-arid region. Even farmers living in the banks of canals and rivers, like many in our study area in the São Francisco Basin, have suffered the consequences of droughts (SOBRAL *et al.,* 2018). In 2015 and 2016, the Sobradinho reservoir reached less than 20% of the total volume (MILHORANCE *et al.,* 2019). This worsened conflicts in the region because power

generation prevails as a priority despite the high irrigation demands, causing losses to farmers and riverside dwellers and hindering the supply of food to urban areas (NOBRE *et al.,* 2019). The already high global demand for water, together with the fact that irrigation is one of the strategies used for adaptation, will lead to more disputes in the face of climatic changes (HERWEHE; SCOTT, 2018).

Here we can see the relevance of the Cisterns Program, strengthening the specific capacity of farmers in dealing with climatic risks through the possibility of storing water for prolonged periods and developing small irrigation projects in their property. This goes against the extensive irrigation projects, which have already been shown to increase farmers' vulnerability during prolonged droughts (GUJJA *et al.,* 2009; YU *et al.,* 2009). The role of the more efficient irrigation techniques with less need for manual labour is highlighted by Herwehe and Scott (2018). In the study, along with the diversification of income sources, efficient irrigation systems, such as micro-sprinkler or drip irrigation (usually received through government programs), were related to mitigating the impacts of drought on family farmers' production Brazilian Semi-arid. However, it is worth noting that the appeal for water conservation was not the main rationale used by farmers. Still, rather than reducing manual labour and soil degradation, water conservation and saving for times of extreme drought was seen as a lateral benefit. Environmental management practices, including water management through rainwater collection, are a common risk reduction strategy in the face of climate change around the world (BURNHAM; MA, 2016).

Several productive kits that complement the social technology and are selected according to local needs include simplified irrigation systems, such as drip hoses. Therefore, the Program, besides being an inducer of the water-food nexus, can strengthen critical specific capacities in a climate change context, especially when aligned with other policies, such as those under the Zero Hunger Program. As Lemos (2016b) points out, the idea is that structural deficits linked to generic capacities and climate risks can be addressed together in favour of greater adaptive capacity through synergies between programs related to climate adaptation and rural development.

5 CONCLUSIONS

From the perceptions of farmers and institutional actors involved with the Cisterns, it was possible to understand how the extensive drought period impacted production systems and how the Program has been helping to increase adaptive capacity. Access to the Program, together with others in which beneficiaries participate (such as the Family Allowance Program), can be seen as a means of strengthening the relationship between water and food security and the generic and specific capacity of farmers through synergies between impacts directly related to poverty reduction and others linked to climate adaptation. As noted, climate extremes have caused impacts in semi-arid areas in Brazil and other developing countries (Ex: Myanmar, Swe *et al.* 2015), influencing the successful implementation of social programs. Based on this, we conclude with some suggestions for water infrastructure programs in semi-arid regions worldwide.

First, related to climate scenarios, the entire climate dimension should be considered during the planning of programs as a way to achieve an adaptive social protection strategy, making it more resilient to the most diverse types of shocks, including current and future climate variability effects (BÉNÉ; CORNELIUS; HOWLAND, 2018; BÉNÉ; NEWSHAM, 2011; DAVIES *et al.*, 2009). Within this framework, great attention is paid to the need of integrating social protection, with risk reduction and adaptation to climate change, achieved through the improvement of knowledge and data on risks and needs, as well as on the success of specific strategies, increasing the capacity of programs and beneficiaries to respond to shocks (BOWEN *et al.*, 2020).

Programs' planning must also consider extreme rain events, considering the lifespan and the construction processes of water infrastructures, aiming to construct additional structures (ex: barriers,

dams) that store spare volume during large rain events. Such importance is even more significant given the diverse uses of these technologies. Here, there were reports of domestic use (for cooking, washing) of the water stored in the 2nd water cistern, which indicates that there is still a deficiency in the stock for home use, possibly reducing the program impact on production. Implementing programs must consider climatic patterns and regions' projections, observing planting periods of the leading regional crops. Productive kits, delivered along with social technologies, also need to be considered in this context since the loss of inputs with extremes of climate was observed. In extreme climate situations, technicians' visit is also essential, being an opportunity to address other less practical issues, such as the diffusion of climate knowledge. For this, guidance and training on the impact of climate change and mitigation and adaptation actions in the rural area are essential.

Regarding this process, it is suggested that all programs in areas considered climate hotspots include the preparation of courses and materials of easy assimilation aimed at expanding climate knowledge of different actors, in addition to beneficiaries. For the latter, more excellent expertise about climate change can influence planning and early adaptation to future events, including reducing the refusal to join programs during rainy seasons (due to misperception that drought is gone). Due to the importance of soil conservation, together with that of collecting water and adjusting production to droughts (drought-resistant species) to adapt to climate change in more arid areas (KALUNGU; LEAL FILHO, 2018), such materials should expand knowledge about the benefits of soil and biome conservation, and agroecological practices in the face of climate change. Still, discussing extreme climate impacts on animals and plants and ways of adapting should also be included. This process can be combined with other strategies, such as the diffusion of climate knowledge through booklets and lectures in countryside schools (LITRE *et al.*, 2017). Water infrastructure programs, aligned with the inclusion of small, efficient irrigation systems, also favour savings of farmers' time and less soil degradation, as demonstrated by Herwehe and Scott (2018).

And, finally, in the scope of program planning, one must think about the articulation of water infrastructure programs with other strategies (ex: water reuse programs, rural insurance, school meals, etc.), so positive synergies can be exploited as a result of better planning (MILHORANCE *et al.*, 2019, 2020). Despite the sometimes-limited effect of more drought-oriented programs on strengthening adaptive capacity, the active participation of farmers, together with broader poverty alleviation programs with which the same populations are associated, can address both specific and generic needs, promoting long-term changes necessary in a scenario of climate change.

NOTES

1 | 1906 – Ifocs (Federal Inspectorate of Works against Drought); in 1909 became Iocs (Inspectorate of Works against Drought); and in 1945, Dnocs (National Department for Works Against Drought). [2] Law nº 12.873 / 2013, regulated by Decree nº 9.606/2018.

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Nature vs policy: drought and famine in the northeast of Brazil, 1877-79

Gerenciamento dos resíduos têxteis pré-consumo da indústria de confecção do vestuário em Teresina/PI

James Augusto Pires Tiburcio [1]

[1] *PhD in Sustainable Development, Director, Instituto de Reflorestamento Eden, São Luís, MA, Brazil*
E-mail: james.tiburcio@edenprojects.org

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ABSTRACT

Droughts followed by famines were common in Brazil, mainly in Northeast Brazil, until the 1980s and were frequently devastating, destroying livelihoods. A succession of droughts resulted in harvest failure, triggering famines in some cases. Famine-like conditions prevailed mainly in the 1877-79 Grande Seca (Great Drought), in which many died of malnutrition-related causes. In subsequent droughts, famine-like conditions reoccurred, but the extent of starvation-induced deaths declined to almost zero. Do only available political theories and known natural and socio-political factors, such as climate, topography, and market viability, provide sufficient data to investigate the causes of the drought of 1877-1879? The author concludes that there is little or no research, accumulated knowledge and information on the possible factors that satisfactorily explain why the drought and famine episodes were so impactful in that period.

Keywords: Drought. Famine. Northeast of Brazil. Grande Seca. Geographical Nature.

RESUMO

Secas seguidas de fome eram comuns no Brasil, especialmente no Nordeste, até a década de 1980, sendo frequentemente devastadoras, destruindo meios de subsistência. Uma sucessão de secas resultou no fracasso da colheita, desencadeando carestia em alguns casos. Condições semelhantes à carestia prevaleceram particularmente na Grande Seca (Grande Seca) de 1877-79, na qual muitos morreram de causas relacionadas à desnutrição. Nas secas subsequentes, condições semelhantes à carestia voltaram a ocorrer, mas a extensão das mortes induzidas pela fome caiu para quase zero. Apenas as teorias políticas disponíveis e fatores naturais e sociopolíticos conhecidos, como clima, topografia e viabilidade de mercado, fornecem dados suficientes para uma investigação das causas da carestia em meio à seca de 1877-1879? A conclusão do autor é que há pouca ou nenhuma pesquisa, conhecimento acumulado e informações sobre os possíveis fatores que explicam de forma satisfatória porque os episódios de seca e fome foram tão impactantes naquele período.

Palavras-chave: Seca. Fome. Nordeste do Brasil. Grande Seca. Natureza geográfica.

1 INTRODUCTION

Most analyses of droughts and destruction of livelihoods and the famines that follow are a mix of Malthusian traditions of “natural” versus “manmade”. Roy (2016) argues that, in Indianist literature,

manmade can also mean cultural dogmas that moulded the scope of private charity aimed at mitigating the consequences of disasters. Robust evidence and analyses show that most Brazilian droughts were almost entirely caused by the El Niño Southern Oscillation (Enso) phenomenon (SINGH *et al.*, 2018). In 20th century Brazil, there was much debate concerning whether the resulting famines were natural or manmade. A preexisting history of bad diet and malnutrition is often blamed for devastating effects following demand and supply shocks (ROY, 2016). Manmade ones usually refer to famines with a politically motivated action that shifts food supply away from one group to another, especially as a function of state action or inaction behind them. The state's role cannot be downplayed as famine relief, in the sense of an organised effort to reduce starvation in a region affected by famine, usually is not priced nor refused by anyone (DENG; MINEAR, 1992).

Some have argued that state famine relief has on occasion failed in situations of, for example, protracted political crises, which resulted in sectarian or predatory reactions to socioeconomic stress and marginalisation (DUFFIELD, 1994). Others have blamed ideological biases that prevent states from doing more, for example, in the Great Famine in Ireland or the famines in India during the British Raj period (STAHL, 2016).

Despite being among one of the most populated semiarid regions globally, overpopulation was never a significant factor in analyses of the Brazilian *Sertão* famines, despite some noteworthy mentions (SENA *et al.*, 2018). Bertola and Ocampo (2012) mention overpopulation in the Brazilian Northeast; however, contemporaries saw the *Sertão* as a depopulated expanse, victimised by diseases and droughts (BLAKE, 2003). The Northeast population was and still is the second largest in Brazil. However, the demographic density of this region has always been low as it occupies an extensive territory. Estimates of the pre-conquest population of Brazil as a whole and that of the Northeast are problematic. Most probably, the whole territory's population was somewhere between 1 and 3 million (MADDISON, 1992). And there was, admittedly, a demographic collapse of the first peoples' population in the first 2 centuries of European presence (NEWSON, 1993). Nonetheless, many have suffered one or another sort of stigma from other regions since the first documented migrations triggered by droughts (ALBUQUERQUE JÚNIOR, 2017). In the 1870s, the Northeast of Brazil was not regarded as a separate region as it came to be in the 20th century (MELO, 1984). Instead, it was part of the provinces of the North, an area that stretched from the Amazonas to Bahia, in opposition to the South that went from Espírito Santo to Rio Grande (GREENFIELD, 1992).

In the Brazilian backwaters, state relief in the 20th century was not hampered by an ideology that defended weak relief; there were no wars, despotic regimes, or even state collapses. There were political factors, as there were no absolute and general food shortage circumstances and no deliberate obstacles to the supply and distribution of food (Ó GRÁDA, 2007). However, the vulnerable agrarian environment was always present, mainly due to the intellectual influence of positivist faith in the use of technical expertise, without any consideration for the socio-economic context in which the same technique would be deployed (BUCKLEY, 2010).

I use literature and theoretical review to identify gaps in current research understanding of the political theories, natural and political factors that investigate the causes of the drought of 1877-1879. In so doing, I locate my research within this context, tracing progression in the field, identifying gaps, and suggesting how future research may elucidate present contradictory conclusions. The limitations of this research article are closely linked to the limited number of consulted bibliographies, characteristic of non-systematic reviews. However, the perspectives presented are representative of state of art in the field.

2 GEOGRAPHICAL APPROACHES TO BRAZILIAN FAMINE CONDITIONS: TESTING THE USEFULNESS OF MANMADE VERSUS NATURAL ANALYSES

As in most of Asia, Africa, and the Americas, records of droughts and famines became available following the European invasion, though their occurrence has an unknowable unrecorded history. In Brazil's case, systematic documentation is very recent, an innovation brought by the Portuguese crown

in 1808 and only systematised and institutionalised in the 20th century. A bias regarding manmade analyses is intrinsically overlapped by a European colonial reading of all phenomena (ALVES, 2003).

Droughts which resulted in famine-like conditions that led to deaths were more frequent in the 19th century, still happened in the 20th and ceased altogether in the 21st (at least so far). In this regard, the region followed the global trend. A decline in famines is inversely correlated with population growth, resulting in a permanent decrease in mortality rates and a demographic transition. A simple test to verify the usefulness of the manmade versus natural analyses as causal models should explain the frequency of famine-like situations and the rarity of a single factor. In the Northeast of Brazil, the last drought that resulted in famine-like cases was the 1979-83 (or 1985) (BRITO *et al.*, 2018).

Documented episodes of famine-like conditions in Brazil are available from the beginning of the Portuguese invasion. The first known record was made in a letter by a Jesuit Roman Catholic priest, Father Antonio Pires in 1552 (VILLA, 2000). In his *Carta de Pernambuco em 5 de junho de 1552 aos Padres de Portugal*, Pires, cited by Navarro (1988), affirms that, "[a]nd so there were four or five years that it didn't rain on it, and this year it rained so much that they collected so much food that it is staggering, and those of the land are persuaded that because of the sins that it didn't rain: They praise God a lot" (NAVARRO, 1988, p. 123 [author's translation]).

More than 30 years later, another Jesuit, Fernão Cardim, describes a drought in Brazil.

> The year of '83 was such a great dryness and barrenness in this province (a rare and unaccustomed thing, because it is a land of continuous rains) the water mills did not grind much time. The plantations of sugar cane and cassava were dried up, where there was a great famine, mainly in the backlands of Pernambuco; after that, they descended from the hinterland, hunger-stricken, and were assisted by the whites some four or five thousand Indians. But after that work of famine, those who could have turned to the hinterland, except those who stayed with the whites, or by their own, or without their will (CARDIM, 1980, p. 69 [author's translation]).

Seventeenth-century records are scarce and vary about dates. Eighteenth-century records are found on the occurrence of ten droughts with several divergences regarding locations and dates, the most accepted ones: 1709/1711 (Maranhão), 1721-25 or 1723-27 (Ceará and Rio Grande do Norte), 1736-37, 1745-46, 1754, 1760, 1766, 1772, 1776-78 (a severe drought that coincided with an outbreak of smallpox) and 1791-93, a lack that transformed part of the population into beggars.

In the eighteenth century, there was a drought in every decade in the then Northern Provinces (GONÇALVES, 2018). For four times a period of lack of five consecutive years has been recorded in contemporary Brazilian history: 1876 to 1880, then again at the beginning of the 20th- century, from 1901 to 1905, 1929 to 1933, and 1979 to 1983. However, the most extended period ever registered took place between 2012 to 2017 (BRITO *et al.*, 2018).

In the last quarter of the nineteenth century, between 1877 and 1878, the *Grande Seca* caused the deaths of between 400 and 500 thousand people. Of the 800 thousand who inhabited the Northeastern region, 168 thousand migrated to other parts of Brazil. In tandem with parts of Asia and Africa, it was part of the deadliest disaster ever registered, 30 to 60 million people worldwide were victimised, and there were enduring consequences (SINGH *et al.*, 2018).

In Northeast Brazil, a significant crop failure occurred, intensified by an incipient agricultural management environment, overgrazing, sharecropping, inadequate preparation, and government response (CAMPOS, 2015). The twentieth century was not much better as, for example, between 1979 and 1984, there were famine-related deaths, apart from an unknown number of infirmities derived from malnutrition, especially among children, as a direct result of the drought which scorched the Brazilian

Northeast in those years (VASCONCELOS, 2020). Interestingly, Brazil does not figure in the 20th-century famines death table compiled by Hasell and Roser (2013), although the 1896-1900 Famine is listed.

Before the Famine of 1877-79, an unknown but significant percentage of the population was already suffering from a chronic state of nutritional deficiencies that, with a little less food, would lead to hunger and death from diseases associated with malnutrition. Many of those affected – the *flagelados* – were already on the brink of the precipice, living debilitated lives in a region that had not experienced drought since the 1840s but had an economy in crisis due to the general fall in the prices of exported products (FURTADO, 1971).

There is an unexplained relation for the proximate economic cause of famine in Brazil to rise in food prices, which reduced real wages, resulting in starvation of impoverished farmers and farmhands. However, explaining the increase in food prices with supply shocks, such as harvest failure or demand shocks, is problematic. And the relationship between the economic crises, costs of the region's export products, the ruling class, and the landowners and workers are at best challenging to evaluate. The financial problems, the fall in the price of the region's export products, a kleptocratic ruling class that was experiencing progressive loss of space in national politics, social destabilisation with the ineffectiveness of the protection and submission relationship between landowners and workers, all these unknown relationships make it impossible to predict any stable quantitative relationship between the degree of stress and the extent of price rise (ROGERS, 2010).

In retrospect, the early 1870s in the Northeast can be seen as years that seemed to lead to disaster as one regional crisis pushed another inevitably. The recession of the early 1870s was followed by a significant fall in the price of cotton, which was an important export crop for the region. The financial crisis followed, and sugar cane exports were also hit. *A moléstia da cana,* a cane disease that attacked the plant leaving a yellow soluble mucilage in the sugar boilers that interrupted the manufacturing operation, also contributed to the decline of the Brazilian cane plantations and the deterioration of livelihoods in the Northeast, leading to the great famine of the late 1870s (EISENBERG, 1974). Coffee continued to expand in the Southeast, while cotton, sugar, and tobacco production and exporting did not stop to contract as hundreds of thousands emigrated to the Amazon region and enslaved people were "exported" to the coffee regions (ABREU; LAGO, 2015).

The causes of the periodic droughts have long been known to be climate-related (MAGALHÃES, 2017). The issue at hand is the famines that followed. Supply shocks seem to have been at the heart of price shocks in the region according to a theory of geographical roots for the famine that followed in the 1870s and those that continued to take place at irregular intervals. According to this theory, uncertainty over the rains in a hot and dry arid interior directly influenced harvests and food supplies, blaming natural conditions, ecology for sharp fluctuations. This theory was articulated and defended by the first fact-finding missions to the region. The *Inspetoria de Obras Contra as Secas* (IOCS) was created only in 1909. The other official responses to drought and famine in the Northeast, by and large, contended that cattle-grazing and subsistence farming that depended on seasonal rains, leading to low productivity and ever-present harvest failure risk, were responsible for the resulting famines and that the lack of development of the available resources was the main reason for the calamities (CAMPOS, 2014).

Some blamed the people themselves for the situation they were going through (GREENFIELD, 2001; HADDAD, 2018). The middle path view disputed the assumption that droughts could not be mitigated by human intervention or that nothing could be done to minimise the effects of the drought (CAMPOS, 2014). Following those initial assessments, public policies were directed to address the effects of the droughts, changing attitudes and actions, resulting in the formation of commissions and government bodies to implement relief works, at first tackling water supply issues, in what became known as the "hydraulic missions", with the commissioning of studies for the construction of reservoirs (MOLLE *et al.*, 2009).

The question arises whether the connection of famines with the supply of water was correct or not. Rainfall patterns and average temperature changed very little in the ensuing years. The *Grande Seca*

took place between 1877 to 1879, or 1880, the first large reservoir (açude) was commissioned by the Ministry of Agricultural Affairs in 1879. The planning project was concluded in 1882, while the dam itself was completed in 1906. In the following 75 years, infrastructure in the Northeast came from close to zero to desirable levels in most regions, including reservoirs, roads, railroads, waterways, and technical assistance in general. However, droughts and hunger continued to affect particularly subsistence farmers throughout the 20th century negatively. The technical solution remained elusive (CAMPOS, 2014).

Would a geographical view of famine emphasising trade costs rather than harvest shocks be more appropriate to the Brazilian Northeast? From this perspective, inflation during famines would result from failures in supply chains due to deficient market infrastructure. A market failure could be held responsible for, for example, the *Grande Seca* famine as, relative to the scale of the harvest shock, the Brazilian domestic market was too weak to move general provisions to the most affected regions. This notion is taken from Roy (2016) and applied to the Brazilian case. If we were to emphasise the geographical approach on trade costs instead of harvest shocks, inflation would have resulted from failures in supply, which are a result of the market infrastructure. As far as I am aware, there are no statistical and econometric studies analysing the capacity of the Northeastern grain market or that of the Brazilian one to move enough quantities to the region to offset the famine of the late 1870s. One would speculate that the lack of railroads and just good roads, in general, would have made such an undertaking extremely expensive, and the buying power of the local populations would have been close to zero. The gradual improvement of the region's infrastructure along the 20th century allowed essential food items to be moved at cheaper rates; that is, the growth in road connection led to lower trading costs and the decrease in famine-related deaths. Trade would have certainly been a mitigating factor under such conditions.

The *Agreste* region in the 1870s was isolated both in terms of transport and communication. Bulk transportation was almost non-existent, and the long distances affected the quality and speed of response to emergencies, such as droughts that resulted in famine-like situations (TIBURCIO, 2015). But it is not clear whether marginally speedier information, better trade, and better road infrastructure would have prevented the human and economic costs of the droughts (HANDMER *et al.*, 2012).

Borrowing from Milton Santos (2005) and his concept of the centrality of the periphery, despite *Agreste*'s isolation and peripherical relegation, it was paradoxically central to the Brazilian Empire (MELGAÇO; PROUSE, 2017). The same author points to the metamorphosis from a rural world to an urban one characterised by environmental conditions that no longer sustained life and resorting to an anthropomorphising allegory; he asserts that nature ceases to be friendly and becomes hostile (SANTOS, 1988). That seems to have been the case of the Brazilian *Agreste* in the late 1870s.

3 THE POLITICAL HYPOTHESIS OF FAMINES IN BRAZIL: POLITICAL APPROACHES TO BRAZILIAN FAMINE CONDITIONS

Dom Pedro II, emperor of Brazil between 1831 and 1889, ruled the country by and large through a functional representative monarchy for the wealthy and white, and despite his infamous, and maybe apocryphal quip regarding the sale of crown jewels to prevent more famine deaths in the Northeast, his government seemed to desire to do something to minimise the situation genuinely. It did very little, and the accusation that the Brazilian Imperial state did less than it could during the great famine and made things worse by its submission to British trade policy is factual and well-seated in general history textbooks.

Until the 1950s, the ecological account held strong in Brazilian economic and policy history literature: the primary cause for droughts and famines was a natural or climatic phenomenon, and that was as an axiom (ABREU, 2015). Some intellectuals and social reformers at the time believed that a perpetual weakness of the *sertanejos* was laid bare by the droughts and that they would only experience political and social reform once the populace and the land they occupied was reorganised in smallholder

colonies that would produce for local needs, diminishing the grip the elites had on all aspects of life in the *sertão* (ABREU, 2015; BUCKLEY, 2010).

Amartya Sen, the most influential theorist of famines in the 19th and 20th centuries, hinged his thesis on the consequences of colonial rule, first explaining the causation of starvation and the degree of exposure of people using the 'entitlement' approach (SEN, 1976). Sen's theory establishes that price shocks may arise independently of supply shocks, resulting in a severe fall in real wages regarding food prices, ending in a famine. He does not provide a generalisable hypothesis on why price shocks may occur in the absence of supply shocks (PLÜMPER; NEUMAYER, 2007).

To Sen (1976), by not meeting its social obligations, indifference, and/or placing the responsibility in the markets, the British colonial government tolerated market failure and merchants' speculative hoarding leading to famine. Bowbrick (1986) refutes Sen's famine theory by arguing that Sen used unreliable and inaccurate statistics. However, Sen's influence in famine relief analysis permeates most scholarship in the subject. Its indictment of colonial governments' apathy, inaction, and market failures ingrained food policy into humanitarian crises (TIBURCIO, 2015). Colonialism became a byword for famine, especially in south Asia and Africa.

His view that famine and drought relief should be a contractual obligation and that inadequate relief considered a breach of that social contract underlies most subsequent research. Sen's theory limits the reach of any ecological account. It points to inequality in "entitlement to food" in any significant food crisis as the right place to look for explanations to the effects of one (OSMANI, 2000). Sen shifted lay and expert views against free and less regulated markets (SEN, 1983). However, Sen's explanation is not supported by historical evidence (PEACOCK, 2010; RAVALLION, 1987).

Before Sen, Castro (1946, 1952), influenced by Social Catholicism, Myrdal (1968)'s poverty cycle, and La Blanche (1954)'s geography linking biology and sociology – connecting human nutrition and the characteristics of social organisation – rejected many of the socio-economic beliefs regarding drought and famine that prevailed in his time, some of which are still fashionable nowadays (BRADY, 2008; MISSIO *et al.*, 2015; TARANTO, 1980). The author espoused an empirical theory that went against some of the tenets of the positivist thought that dominated Brazilian drought and famine response from the imperial period to the 1960s. Castro (1946, 1952, 1954) strengthened his hypothesis that hunger in the Brazilian Northeast was neither related to the quantity of food nor the number of inhabitants; instead, it was a wealth distribution issue, intimately associated with the increasing concentration of land in the hand of a few (VASCONCELOS, 2008). He advocated that expanding food production was not the solution but rather the distribution of resources and land (CASTRO, 1967). He also mapped the distribution and concentration of hunger in Brazil to discredit prejudiced causes that are still routinely used contemporarily, especially the supposed idleness of the Northeastern people and the climate (CASTRO, 1952).

To Castro (1960), local and national politics and unbalanced social and economic relations were behind hunger, malnutrition, and not natural factors. "Hunger is not a natural phenomenon, but an artificial product of defective economic conditions. A product of human creation and therefore liable to being eliminated by the will of man himself" (CASTRO, 1960, p. 60). However, some of Castro's correlations and explanations were spurious, and he was not too concerned about "the canons of scientific procedure" (MAGALHÃES, 1997, p. 16). He was, above all, an activist against hunger (FAIRCHILD, 1952).

4 THE NATURE OF THE STATE AND DROUGHT AND FAMINE IN BRAZIL

The nature of the state cannot explain the cessation of famines in Brazil. The end of the imperial period in 1889 had little to no effect on the economy and social fabric of the Brazilian Northeast. In 1876-79, it was easy to underestimate supply shocks and overestimate market failures as the poor population was

nearing destitution in most drought-prone regions. A prolonged mismatch between people and food production and trade peaked when the drought struck (GREENFIELD, 1992).

There were diminishing returns to agriculture in much of the Northeast, especially in Ceará in the 1870s. As sharecroppers, landless farmers and farmhands struggled to pay their rents with crops and labour. Survival was conditioned by a limited spectrum of livelihood options: subsistence and small-scale farming, and hired labour to landlords, apart from seasonal work in sugarcane and cotton plantations in some regions (BUCKLEY, 2010).

The nature of the state in Brazil and famine, and whether they may be classified as manmade and made worse by the slow hand of the state, is the question regarding the intentionality of the failure, that is, of the state failing to act. Regarding the 1877-79 drought and famine, seeing it as a "manmade" crisis entails claiming that there was deliberate state failure and not simply economic issues about production in a context of repeated droughts. To advocate this hypothesis, one would have to assume that the Brazilian state was given an exogenous level of state capacity, equipped to provide relief effectively, but that it had calculatingly underutilised it (HALL-MATTHEWS, 2008). And importantly, to support this view, politicians would have to be free agents and, therefore, liable in case of inaction, as famine relief would have been a matter of free choice. To evaluate such a situation in 1870s Brazil is an almost impossible task due to a lack of data for the period (FAGAN, 2008).

But could the Brazilian state have acted to prevent the 1877-79 famine effectively? Droughts and famines compromise state capacity. No matter how well prepared, as variability in the scale of natural disasters is an intrinsic feature, no preparedness or size of insurance can genuinely cope with a systemic disaster. In other words, the issue in Brazil was systemic, as the variability of scale entails that those government agents given the responsibility to prepare state capabilities were systematically underprepared. The Imperial government's presence in the Northeast in the 1870s, as in most of the country except in some coastal urban centres, was sparse. The Empire of Brazil was a decentralised monarchy, with each province having a provincial legislative assembly that had much autonomy in varied matters. The national government appointed the president of the province. Still, the day-to-day affairs of the province were run by the *de facto* governor, the vice-president who was elected by the local, provincial assembly (VALENÇA, 1999). Provincial politics was a patronage game involving the exchange of favours between the most powerful families of each region, the "colonel's regime", a local strongman that defined everything in their area (JANOTTI, 1981).

The droughts and famine of the 1870s were not unforeseeable, but there were no insurance policies or any preparation in place, either by the local elites or the imperial government. The situation weakened the already weak state. Variability of scale is an ever-present problem for historians and policymakers alike. Although the class of events predicted to occur is not new, the scale is always a novelty (WILHITE *et al.*, 2014). In this way, in the 1870s, the Brazilian government and the people were unprepared as matching state and societal capacity with the scale of the problem was a continued failure.

In the 1870s and subsequent decades, the government's reaction took a generation to take effect, as the state's presence and resources to collect data and act on it were limited and poorly managed. In December 1877, the Emperor created the Imperial Commission to study the causes and actions to fight drought and famine in the Northeast. The commission's report recommended the construction of three railways, 30 dams, meteorological observation posts, and the opening of a canal linking the largest regional river, the São Francisco, to the Jaguaribe River, apart from the importation of camels (RINALDO, 2017).

The Brazilian Imperial government in the Northeast of Brazil in the 1870s was a weak state; the density of its network of local administration was at best flimsy, and at worse, non-existent, with minimal penetration in the deepest *Agreste*. Representatives of the state and imperial government rarely visited the worst affected areas, and travel was difficult. The provincial government only started to become aware of the seriousness of the situation when starving; emaciated *retirantes* started to crowd coastal towns (NEVES, 2000). Those that survived trekking through the deserted interior were encouraged to migrate to the Amazon region, to the Southeast – Rio de Janeiro and São Paulo, anywhere, as long as it was far away (FAGAN, 2009).

Notwithstanding Dom Pedro II pledge to end droughts in the Northeast, his crown's means were limited: the provincial and imperial governments had scant reliable and scientifically collected data, inadequate transport and communication infrastructure, and corresponding fiscal capacity. Still, the Crown was fiscally solvent for most of the Imperial period (1822-1889), as "the Brazilian fiscal policy, as it was demonstrated [...] [exhibited] a genuinely 'Ricardian' behaviour, realising fiscal adjustments and utilising the internal and external debt efficiently as a way to attain the intertemporal balance." (RUIZ-DE-GAMBOA; SUMMERHILL, 2009, p. 3).

But, apart from that, for much of the late Empire and the First Republic, Brazil was beset by oligarchic patrimonialism and a long-ingrained system of electoral clientelism (QUIMPO, 2005). At the same time, local public and private resources were limited, as the Northeast's growth rate was close to zero, or just negative for the 1822 to 1850 period, followed by marginally better growth rates between 1850 and the early 1870s, and again negative growth rates between 1875 and 1889 (ABREU; LAGO, 2010).

Although the 1877-79 drought compromised state capacity, it did lead to some organisation by the state to prevent the worst with the introduction of a relief system based mostly on regional public works (CAMPOS, 2015). Dandaro and Marcondes (2018) show that the Ministry of Public Works (MOP) expenditures until 1914 were realised in periods of drought. Most of them were directed to relief work to those directly affected by the droughts. The first drought in the First Republic took place from 1898 to 1900 in the Campos Sales government. The federal government did very little, denying most of the Northeastern governors' requests for aid, claiming they would destabilise the budget (VILLA, 2000).

Information and scientific knowledge about weather and agriculture were starting to be seen as indispensable to battle droughts and famines. An increase in the volume of data produced became available to the Imperial cabinet (GREENFIELD, 1992). Gonçalves (2018) argues that the Brazilian Empire spurned by Dom Pedro II followed the scientific search for a markedly positivist solution to the drought and famine conundrum. The Brazilian state pursued a hydraulic solution to the water shortage issue and related matters from 1877 to the early 1950s (MOLLE *et al.*, 2009).

The first general director of the IOCS, Arrojado Lisboa, understood the relevance of information regarding technical and scientific knowledge and invested in research that resulted in valuable studies that guided government policy (CAMPOS, 2015). Information was irrevocably established as a basis for policy formulation (CAMPOS, 2014).

But, back in 1877-79, the geographical distances between the worst affected areas and the state seats of power made information about local living conditions, economic, market and trade networks limited and infrequent, affecting the quality and speed of response to droughts and famines in a context that was already marked my inefficient and insulated government entities. The news of the situation claimed some contemporary accounts, only reached the state capitals with the *flagelados*, as thousands fled to coastal towns searching for food and shelter (GREENFIELD, 1992).

Nevertheless, there was some information gathering and dissemination effort, especially one promoted by a firm belief in the newish positivist science, as printed on the *O Retirante* newspaper in March 1878:

> Let us all trust Providence but let us not rest. To prepare tomorrow the effect of indolence, the society that rests today accumulates evils that, duplicated, sometimes become incurable. Therefore, it is necessary to continue to study the determining causes of drought in the regions now plagued by this scourge and prepare the required elements of resistance for the future. The medicine that has to cure Ceará and its northern sisters are not, and cannot be, hydropathic; it is a medicine of high politics, predictions, studies, courage, and patriotism. (O RETIRANTE, 1878, p. 2-3; GONÇALVES, 2018, p. 516). [Translation by the author].

Weather prediction gained importance in famine prevention in Brazil as meteorological stations and observation were part of the proposals of the Imperial Commission of 1856. Experts gathered at a

Historical and Geographical Brazilian Institute (IHGB) session recommended the establishment of meteorological stations that would observe and record phenomena, help predict droughts, and better prepare a government response. Weather prediction would be of critical importance to prevent future famine-conducive conditions (BUCKLEY, 2010). But they were debating, and no actual proposals or plans resulted from the exchanges except for the *Açude do Cedro*, the Cedar Weir, in Quixadá, state of Ceará. No action was taken for decades to come.

A smallpox epidemic accompanied the 1877-79 drought in Fortaleza, the capital of the state at the epicentre of the famine (COSTA, 2004). One of the catalysing factors in the high number of deaths in the 1877-79 famine was the lack of preventive anti-epidemic measures, especially in the agglomerations to which some of the *flagelados* were forced to stay (BARRETO *et al.*, 2011). The relationship between social crises, famines, and epidemic diseases is still an ongoing debate with ample literature, but there is much evidence of their lethal interplay (ARNOLD, 1993; HIONIDOU, 2002).

5 MIGRATIONS, CULTURE AND THE STATE

In the 1877-79 drought, the Brazilian empire facilitated emigration to the Amazon, allowing part of the population to flee the drought and famine and work in the rubber cycle period. In 1915, the Republican state quarantined some internally displaced people in concentration camps. The camps were laid out in a swampy region in the district of Otávio Bonfim and Senador Pompeu, Ipu and Crato in the Northeastern state of Ceará. These hunger camps were designed to confine drought-affected northeasterners. Some 8 thousand people of all ages were kept in poor housing conditions, with little or no clean water; most were jobless and constantly hungry to keep the capital free of the chaos, misery, disease, and dirt that the flagelados brought with them (TEÓFILO, 1980). Behind the creation of camps were the beliefs of politicians and their advisers that were influenced by the hygienist and eugenicist pseudo-science that permeated much of public policy in Brazil in the early 20th century (FERREIRA; DANTAS, 2001).

Famines lead to deaths directly by diminishing food availability. Higher prices make food unaffordable and expose the already weakened and vulnerable population to contaminated water and food sources. Hunger weakens the immune system, and “between starvation and death, there is nearly always disease” (WORLD HEALTH ORGANIZATION, 2017, p. 30). Advances in anti-epidemic measures and modern medicine, in general, were crucial to an abrupt decline in famine deaths in the 20th century (FIELDING, 1999).

Some state and civil society agents in Brazil believed that most of the fault for the misery and death in the Northeast was to be found with the people themselves: they were lazy and unindustrious. Even for avant-garde scientists of the time, such as, André Rebouças and José Américo dos Santos, the *sertanejos* needed to be rescued from themselves (CAMPOS, 2014). As the drought weakened the state capacity of an already sparsely present state, the sheer scale of the event rendered private and local insurance strategies ineffectual. There was nothing feasible to be done by humans to diminish the intensity of the drought itself. However, channels, reservoirs and forestation could help supply people and livestock with essential water supply (CAMPOS, 2014).

As for its effects on human beings and their livestock, the usual storing of harvest surplus, savings from previous good seasons and trade were insufficient to carry the population of the provinces most affected – Ceará, Piauí, the Rio Grande do Norte, Pernambuco, Paraíba, and Alagoas – through a single drought year, much less through 3 consecutive ones. Private grain stocks in those states were just enough in average years, and some staples were imported from the South. At best, the *Sertanejos* diet was poor, rapadura (unrefined cane sugar), cassava flour, and sun-dried beef. But as the drought prolonged and the stigma of consuming palm as it served as cattle feed was waning, whatever palm available was devoured by humans and cattle (SEDREZ, 2008).

In the 1870s Brazil, one could ask if the imperial regime respected a social contract, and the answer would be that it did not take its obligation very literally. However, the 1877 drought was the necessary trigger for the Empire to try and do something about the continuing economic decline of the Northeast, for example, through the implementation of the *Pompeu-Sinimbú* Project, named after the two senators that proposed it (SOUZA, 2019). The project was sponsored by the Northeastern elites with the support of the Pedro II government, led by the Chief of Cabinet João Sinimbu, and aimed at equating economic differences between the North (Northeast) and the South of Brazil (SOUZA, 2015). In it, one sees the condensation of ideas of market failure, culture, and charity in a nutshell about Brazil as a whole and a self-image of the Northeastern Brazilian elites of the period. All the same, philanthropy failed as the sponsors' capacity was reduced (GREENFIELD, 1986).

The project consisted of taking advantage of the very misfortune of the victims of the drought, exploiting them in what was regarded as "useful work". The two senators proposed an indirect aid policy. To receive government assistance, the *sertanejos* needed to pay for it with their labour, changing what had been a right provided by the law into work in exchange for aid policy. In the long run, the idea was to compensate for the economic imbalance between the North and the South of Brazil with a policy that used the drought and the famine-like conditions it brought as a driver of economic progress through the exploitation of workers rendered destitute in public works (SOUZA, 2019). Public charity in the first republic took centre stage, however, though it also fell short of the needs of the *flagelados* (NUNES, 2009).

6 CONCLUSIONS

The study of political theories and factors, natural phenomena – such as climate, topography, and market viability – do not investigate the causes of the drought of 1877-1879. There is little or no research or even reliable records on most of the critical factors that satisfactorily explain why the drought and famine episodes were so impactful in that period.

The famine associated with the *Grande Seca*, the Great Drought of 1877-1879 in the Brazilian Northeastern, was both political and geographical at its origins. "Political", to the extent that an unknowable weight of the famine was a result of imperial politics. Present research fails to explain the uncommonness of extreme famine-like conditions for most of the imperial period. It presumes that the capacity of the Brazilian imperial state to alleviate famine leading conditions was checked only by its intentions to act, even though it is also implausible as the fundamental concept of the state is either undeveloped or one-dimensional in most of the literature in the field. The geographical weight is confirmedly present, to the extent that the weather shocks and natural and terrain obstacles to trade conjointly led to the famine.

I have also suggested in this article that the effects of geographical or political causes depended on available information and knowledge, which constrained the Brazilian state's capacity to act during the 1877-79 *Grande Seca.* More information collection and knowledge, greater preparation and more specialised response led to less-lethal droughts, with fewer hunger-related deaths, albeit not to their eradication. This hypothesis does not disregard the relevance of either market strength or swings in the political economy ideology behind the set of possible causation drivers for famine conditions in the Brazilian Northeast in the 1870s. It simply adds a third significant element that studies of political and geographical views generally tend to underestimate.

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São Paulo's 2013 water crisis: a socially constructed disaster risk

Crise hídrica em São Paulo de 2013: um risco de desastre socialmente construído

Izabela Penha de Oliveira Santos [1]

Ana Paula Fracalanza [2]

Robert Coates [3]

Jeroen Warner [4]

[1] *PhD in Environmental Science, Programa de Pós-Graduação em Ciência Ambiental, Universidade de São Paulo, São Paulo, Brazil*
E-mail: izabela.santos04@gmail.com

[2] *PhD in Geography, Full Professor, Escola de Artes, Ciências e Humanidades, Universidade de São Paulo, São Paulo, Brazil*
E-mail: fracalan@usp.br

[3] *PhD in Brazilian Studies, Assistant Professor, Department of Sociology Development and Change, Wageningen University & Research, Wageningen, Netherlands*
E-mail: robert.coates@wur.nl

[4] *PhD in Disaster Studies, Associated Professor, Department of Sociology Development and Change, Wageningen University & Research, Wageningen, Netherlands*
E-mail: jeroenwarner@gmail.com

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RESUMO

Frequent cases of water scarcity in Brazil reveal a water governance and administration crisis. During the water crisis (2013-2016), the São Paulo Metropolitan Region experienced a disaster scenario. This article analyses how it was constituted as a socially constructed disaster episode. A case study was carried out in the Novo Recreio neighbourhood (Guarulhos, SP) through ethnographic observations, interviews, and newspaper articles. The results were analysed based on the Pressure and Release Model (PAR). It was concluded that the water crisis period in SPMR has disproportionately affected the Guarulhos population, especially in Novo Recreio. Furthermore, the study demonstrated that public policies and the neighbourhood's territorial formation are related to its population's current frail living

conditions and increased socio-environmental vulnerability in the face of continuous water scarcity, thus corroborating the social construction of the risk of water scarcity.

Palavras-chave: Water. Water Scarcity. Socio-environmental Vulnerability. Environmental Risk.

ABSTRACT

Os frequentes casos de escassez hídrica no Brasil revelam uma crise de gestão e governança da água. Durante a crise hídrica (2013-2016), a Região Metropolitana de São Paulo vivenciou um cenário de desastre. O artigo analisou como a crise hídrica se constituiu como episódio de desastre socialmente construído. Foi realizado um estudo de caso no bairro Novo Recreio (Guarulhos, SP), por meio de observações etnográficas, entrevistas e reportagens de jornais. Os resultados foram analisados com base no modelo Pressure and Release (PAR). Concluiu-se que o período de crise hídrica na RMSP afetou desproporcionalmente a população de Guarulhos, em especial a do Novo Recreio. Demonstrou-se que as políticas públicas e a formação do território do bairro estão relacionadas com a condição frágil de vida atual da população e que aumentaram a condição de vulnerabilidade socioambiental ante a falta de água contínua, portanto, corroboram a construção social do risco da escassez hídrica.

Keywords: Água. Escassez hídrica. Vulnerabilidade Socioambiental. Riscos Ambientais.

1 INTRODUCTION

An impact of climate change is the more frequent experience of extreme drought or flood events. The Economic Commission for Latin America and The Caribbean (ECLAC, 2015) shows that temperature and precipitation patterns change significantly in Latin America and Caribbean countries. Temperature changes affect the precipitation, humidity, and runoff water patterns, decreasing economic activities and water availability for humans and animals. In addition, authors increasingly note that climate variability contributes to the hydric stress of specific populations (BATES et al., 2008; ECLAC, 2015).

São Paulo Metropolitan Region (SPMR) faced a severe drought period named "crise hídrica1" from 2013 to 2016. The event was driven by an unexpected climatological episode of low rainy season precipitation, which was expected to refill the Cantareira reservoir, the main São Paulo reservoir (COELHO; CARDOSO; FIRPO, 2016; MARENGO; ALVES, 2015; NOBRE et al., 2016). However, researchers also highlighted how water supply and water resource management were affected by poor and non-precautionary institutional governance in SPMR (FRACALANZA, 2016; FRACALANZA; FREIRE, 2016; JACOBI; CIBIM; LEÃO, 2015; JACOBI; FRACALANZA; EMPINOTTI, 2017; RIBEIRO, 2011).

Regarding this discussion, the study aimed to understand specific local conditions and public policies involved in how this water crisis had enhanced population vulnerabilities to a disaster point of a lack of water supply. During the crise hídrica, there were reports of households without water for long periods of the day, an increase of informal ways to reserve water, the increase of water and energy costs, and some areas attended by water tankers. However, those effects were not equally distributed around the SPMR and the state. Water scarcity and drinking water provision revealed an unequal resource appropriation and lack of mitigation and adaptation planning for climate variation (FRACALANZA, 2016; MARENGO et al., 2016; SORIANO et al., 2016).

Such impacts can be addressed scientifically as a drought disaster. However, the disaster is not an exceptional natural event of wild nature. Since humans interact, modify and build their socio-political relations, related risks are also produced (BECK, 2011; SORIANO et al., 2016; VEYRET, 2007). Oliver-Smith et al. (2017) argue that tropical storms and droughts can be conveniently classified as natural events, but it is important to note that anthropogenic actions have already modified nature. Especially in cases of drought, natural environments have been modified fundamentally by water and soil use and their management.

Even before disaster events occur, the risk of them happening is known. Sociologists and geographers focus on the vulnerabilities that reinforce a risk and lead to a worse disaster scenario. Most risks are part of peoples' daily lives preceding any extraordinary weather phenomenon. Wisner et al. (2003) explain that exposure differs according to social class, gender, ethnicity, age, disability, etc. Those vulnerability conditions which people are exposed to are directly related to social systems and power instituted by different groups. Therefore, people are more or less harmed depending on their socio-environmental vulnerability.

Thus, the article aims to analyse how the crise hídrica is a socially constructed disaster through the case study of a peripheral SPMR neighbourhood named Novo Recreio in the Guarulhos municipality. For that purpose, the study is based on ethnographic observation, interviews and journalistic reports. The results were analysed through the Pressure and Release Model (PAR) formulated by Blaikie et al. (1994) and Wisner et al. (2003).

Firstly, the article presents the scientific literature about disasters and risks to highlight their relevance and water management. The second topic exposes the case study context grounded in the Novo Recreio neighbourhood. The third topic presents the PAR Model and analyses it to explain how people vulnerabilities enhanced the impacts of the drought. To end, the authors identify new variables to understand urban water scarcity management and point to conditions disregarded by policy-making in SPMR, especially in climate change scenarios.

2 DISASTERS AND RISK AS SOCIO-POLITICAL CONSTRUCTION

The United Nations International Strategy for Disaster Reduction (UNISDR) defines risk as a combination of an event's probability and its negative consequences. Further, the risk is also conceptualised as a statistical expression of damage or economic loss (CASTRO, 1998; UNISDR, 2004). This view understands risk as a disorder in natural environments that the episode's probability and intensity can quantify. The 'hard' sciences mainly work with this perception and create mathematical models to explain and solve disaster risk. However, the social sciences have studied the causes of disasters to identify socio-environmental variables that influence the occurrence of catastrophes.

Beck (2011) brought a sociological lens to environmental and technological risk to understand that western society is a risk society. The author defined the society of risk after all the catastrophic events during the 1980s in Europe. The sociologist argued that western society has lived under radical uncertainty dynamics, which have produced risk conditions with global effects. While bearing this in mind, it is crucial also to frame the specific experience of Latin America, where twentieth-century modernisation created extraordinary urban inequality. Dealing with disaster calls for engaging with the 'modern' complexities of uncertainty and unpredictability that capitalist development has brought forth.

Furthermore, risks are defined through processes of negotiation that need to be understood through normative and symbolic dimensions mediated by social interaction and institutions (BECK, 2011; BOSCO; DI GIULIO, 2015). This risk perspective assumes that there are cultural aspects between the hazard and risk perception. The systematic dispossession, self-construction and improvisation in daily life experiences had built knowledge, and social practices shared among social groups (BOURDIEU, 2004; SPINK, 2014; VALENCIO et al., 2009; WARNER; ENGEL, 2014). The psychological and cultural dimensions of risk are fundamental to understanding the acceptability and hierarchy of certain risks, besides others (MARANDOLA; HOGAN, 2006; SPINK, 2014; WARNER; ENGEL, 2014).

The situation of a social dynamic rupture involves housing, public health, work, authority patterns, social rules and cultural norms disruption, i.e. it defines the social meaning system rupture and consequently shows a limitation to population routine and the need to build a new social dynamic. This is the experience of a social crisis (SENA; VALENCIO, 2008).

During 2015, said to be the worst crise hídrica period in SPMR, Guarulhos's public water and wastewater company (Serviço Autônomo de Água e Esgoto – Saae) intensified water rationing through intermittent provision because the water supply company (Sabesp) decreased the sale of freshwater. This situation imposed profound alterations for Guarulhos's population.

Nevertheless, disasters are produced in everyday life (MARCHEZINI et al., 2017; OLIVER-SMITH et al., 2017; QUARANTELLI, 2016; SPINK, 2014; WISNER et al., 2003). Most disasters are created by normalising risks and the trigger of a hazard, resulting in a socio-environmental rupture. Furthermore, how private and public institutions, NGOs, the media and other social actors define and structure a disaster is essential because they instruct how policies and practices address it.

In the crise hídrica case, São Paulo's government delayed announcing a water scarcity situation due to the elections. It was a period of uncertainty, lack of transparency, and contradictory information (JACOBI; CIBIM; LEÃO, 2015; TADEU, 2016). In Guarulhos, it resulted in a robust and broad campaign for household water economisation to prevent water waste and amplify intermittent drinking water supply.

That decision-making suggests that the municipality of Guarulhos was under water stress for an extended period before the climate hazard. In that sense, it is necessary to examine the vulnerability levels of different social groups, which results in significant social and environmental pressure without observation of the drought hazard (MARCHEZINI; WISNER, 2017; WISNER et al., 2003).

Disaster vulnerability analyses began with 1970's disaster studies that argued the disasters occurred more as a consequence of socio-economic than natural factors (O'KEEFE; WESTGATE; WISNER, 1976) and were, then, followed by Chambers' (1983) development studies, and consolidated in the 1980s and 1990s in a series of books and articles (among them, BLAIKIE et al., 1994; BOHLE; DOWNING; WATTS, 1994; CUTTER, 1996; HEWITT, 1983). Understanding structural vulnerabilities related to race, gender and ethnicity also played an essential role in this perspective.

Vulnerability is distinguished by the characteristics of a person or a social group and the living context that influences their capacity to anticipate, cope with, resist and recover from a hazard impact (WISNER et al., 2003). Vulnerability studies have been done by numerous researchers from diverse theoretical, methodological and ontological premises (ADGER, 2006; ALVES; TORRES, 2006; FREITAS et al., 2012; MARANDOLA; HOGAN, 2006; MARTINS; TAVANTI; SPINK, 2016; O'BRIEN et al., 2013; PORTO, 2011; SPINK, 2014, among others).

In Brazil, Martins, Tavanti and Spink (2016) observed that empirical studies tend to associate more than one condition type of vulnerability, which explains the tendency of researchers to add words to "-vulnerability" to delimitate knowledge fields and governmental interventions. The concept of socio-environmental vulnerability arises through social and environmental overlapping where environmentally degraded areas are superimposed with deteriorating social conditions, amplifying hazard effects and damages (TORRES, 2000). Mainly, this is a current environmental problem scenario where fragile conditions have accumulated in territories as a product of late modernity, by pillaging and segregation processes of socio-environmental inequality (COATES, 2019; LEFF, 2001; MARTINEZ-ALLIER, 2007). In sum, socio-environmental vulnerability results from socio-economic structures that produce precarious living conditions and deteriorated environments that precipitate lower resilience and risk reduction capacity (FREITAS et al., 2012, p. 1578-1579). Thus, historical processes made up of cultural, social, environmental, political and economic contexts are imbricated in patterns of urbanisation that lead to hazard exposure as a result of marginality and access to resources (BANKOFF; FRERKS; HILHORST, 2004; CARDONA et al., 2012; WISNER et al., 2003).

To understand this process, methods and tools have been developed to quantify, index and map vulnerability; conversely, qualitative analyses try to understand community coping capacities involving all social actors, including external expert contributions in action and prevention of risks. Additionally,

there are other frameworks dedicated to empowering society as a broad political agenda. Examples of these models include the socio-ecological model (TURNER et al., 2003), the Pressure and Release (PAR) model (BLAIKIE et al., 1994; WISNER et al., 2003), Community-Based Disaster Risk Management (CBDRM), the Vulnerability and Capacity Assessment (VCA), the Hazards-of-a-place (SoVI – Social Vulnerability Indices) (CUTTER, 1996, 2003; CUTTER; MORATH, 2013), and Social Amplification of risks (KASPERSON et al., 1988).

The present study focuses on recognising the social, economic, and political processes that contribute to increased vulnerability, risk and understanding this process through 'micro' means, practices, and places of daily action. This perspective is embedded in the disaster and political ecology fields. The proposition emphasises the social conditions and root causes of a fragile context, resulting in a cumulative progression of unstable conditions to deal with a threatening situation. Further, this is related to an unequal distribution of risks within specific areas and social groups, resulting in vulnerability and revealing structures of injustice and racism. Indeed, Porto (2011) criticises disaster and vulnerability approaches that do not consider historical origins that transform people's level of vulnerability. The author argues that only accurate historicity can rescue the condition of a citizen-subject of rights (DAGNINO, 2004).

In this sense, the Pressure and Release model is a groundwork that constructs components to explain the increase or decrease of risk probability (BLAIKIE et al., 1994; WISNER; GAILLARD; KELMAN, 2011). The PAR model considers two broad categories – root causes and dynamic pressures – intrinsically bound and generate fragile livelihoods and unsafe conditions and locations. The root causes are related to long-term characteristics such as nations' social and economic structures and their histories and cultures and affect policies and societal relations. In comparison, dynamic pressures are related to short- to medium-term characteristics, including lack of local institutions, local investments, and macro-forces such as rapid population change and development and the world economic market fluctuations. As a consequence of those patterns, the way populations build their lives could result in fragile livelihoods and unsafe conditions. To this extent, the PAR model promotes the consideration of drought disaster beyond a lack of water, bounded within and unearthed inside day-to-day practices in Novo Recreio.

3 WATER SCARCITY ON SPMR: NOVO RECREIO CASE STUDY

Guarulhos, the second biggest city in São Paulo State, has suffered intermittent water supply since 1991. The municipality is located in the Alto Tiete Basin and has two surface dams (Cabuçu and Tanque Grande) joined to underground water supply sources and are responsible for around 12% of the drinking water supply. The other 88% used to be bought from Sabesp2 until 2018. During the crise hídrica, Sabesp attempted to solve the problem by decreasing the water volume transferred to Guarulhos, mainly to benefit São Paulo city. Consequently, under the pressure of water undersupply, SAAE intensified water provision rotation among 17 neighbourhoods in Guarulhos. One of them is Novo Recreio, which has around 4.600 inhabitants living in Cantareira Park, a 'Permanent Protected Area' for environmental conservation. Before the crise hídrica, the household water supply followed this scheme: one day of water provision (24h) alternating with one day without it (24h). However, during the water crisis, the water provision intermittence escalated to 30 hours without water provision and only 18 hours with water supply.

This scenario resulted in a vital concern for public health conditions. Low water provision affects water quality because people search for private means of dealing with the shortage. Firstly, the type of individual response depends on economic conditions: whether to buy bottled water or pursue expenditure for a bigger water tank. Furthermore, the absence of sanitation and housing infrastructure prompts a rise in the prevalence of waterborne diseases, made worse by a lack of public policy in this area (CASTRO, 2010; PAZ; ALMEIDA; GÜNTHER, 2007; VALENCIO, 2009). In Brazil, since 1997, water

management has been based on decentralised, participative and integrated principles. The National Hydric Resources Policy (Federal Law 9.433/1997) determines human and animal drinking water provision as priority users, especially in drought cases. However, Fracalanza (2016) points out that there is unequal water distribution in São Paulo's society, where water access management is addressed to wealthier areas based on the decision making by those who capture and distribute it and thus who can profit and derive economic value from what is ultimately a common good. Sabesp and São Paulo's government decision-making during the water crisis opposed the National and State Water Policies that highlight water as a social resource (São Paulo Law 7.663/1991). Likewise, after the Constitution of 1988, water and sanitation services faced a lack of policies and regulations for the sector. In 2007, it became regulated by the National Basic Sanitation3 Law (11.445/2007)4. This regulatory mark was considered a considerable advance, achieved directly due to social movements' efforts, including those by researchers and other area specialists. It warranted universal access to sanitation services as a citizen right, alongside an approach focused on local parameters and social-institutional control.

Consequently, water resources management laws and the water and sanitation services law consider themselves different administrative sectors instead of an integrated management service. This misconception can lead to unfavourable trade-offs between water reservoir storage and water supply management. Also, in SPMR, it has led to the appropriation and privatisation of water (CUSTÓDIO, 2012; FRACALANZA, 2016; SANTOS, 2021).

Considering this water dilemma and the crise hídrica event, the methodology of this study was developed between 2017 and 2019. This was a qualitative investigation case study (YIN, 2010), based on ethnographic observation registered in a field diary and home visits and qualitative semi-structured interviews with local water managers.

First contact was made to identify locations for the study, gain recognition and establish a good rapport with the community. The healthcare assistants from Novo Recreio's Health Basic Unity and the managers of the Non-Governmental Organization Clube de Mães were the facilitators between the researchers and the dwellers. The twenty home visits and the territory recognition revealed managers and practitioners to be interviewed. Following the snowball technique, the researchers interviewed 13 municipality employees from Saae, Housing and Environmental Secretariats, and two people from the organised civil society. Furthermore, Guarulhos news and official data on local policies related to water supply were collected from Guarulhos Sanitation Policy5, Instituto Brasileiro de Geografia e Estatística6 – IBGE and the Novo Recreio's Health Basic Unity (Unidade Básica de Saúde – UBS Novo Recreio)7. This methodology and study were approved at the Ethic Council as part of the ResNexus Project8.

Later, the results were triangulated to fulfil the categories used by the PAR model. Mainly, the root causes were related to the neighbourhood construction in Guarulhos and SPMR urbanisation. Next, the dynamic pressures and fragile livelihood conditions were triangulated among the house visiting, interviews and official data. Then, the natural hazards were the severe drought and the landslide risk. Finally, the results were combined and critically analysed, indicating the patterns shown in Figure 1 as the flowchart of Novo Recreio's case study.

4 ESTABLISHED WATER CRISIS: A DAILY DISASTER IN NOVO RECREIO

At the beginning of fieldwork, it was observed that Novo Recreio's residents seemed unconcerned about the lack of water provision and that the crise hídrica appeared to be just a temporary condition. The field experience showed that people were used to living without a public water supply. Plus, poverty, the absence of other public infrastructure, and other competing daily risk situations (landslide, expropriation, violence, others) presented greater demands, as a dweller said,

> "Our neighbourhood, you know, it is a recent neighbourhood without any structure despite that our water access is not so difficult like that. We have one day to another without a water supply. Other neighbourhoods stay almost one week without water access [...] we are privileged because there are worse places than ours".

In this sense, Spink (2014) highlights that risk perception needs to consider the meaning of the behaviour considered a risk and the risk behaviour's processes taken by the inhabitants and the hierarchisation of the risks through benefits and costs associated with other risks. Then, the water public disarrangement in Guarulhos and the poor water access as a reality experienced by Novo Recreio's inhabitants created a social imaginary of water scarcity as "everyone's problem". It was reinforced by the local government and the media when public action increases the lack of water supply by saying "people need to avoid wasting water" even if they do not have proper water access.

Moreover, in the face of this normalised situation, other risk and infrastructure problems are hierarchised, such as public transport access, public health service access and the risk of housing displacement. Therefore, a socio-environmental vulnerability condition reveals risk situations that are not external natural factors but also determined by social, political and economic aspects of the social systems (OLIVER-SMITH et al., 2017; SPINK, 2014; WISNER et al., 2003).

This scenario explained how people live under socio-environmental vulnerability and risk. Likewise, the results revealed a progression of vulnerability rooted in Brazil's historical development followed by policies made based on inherited values when applied to the Novo Recreio's neighbourhood create a risk area. Respectively, we present below the PAR model scheme analysed for Novo Recreio (Figure 1).

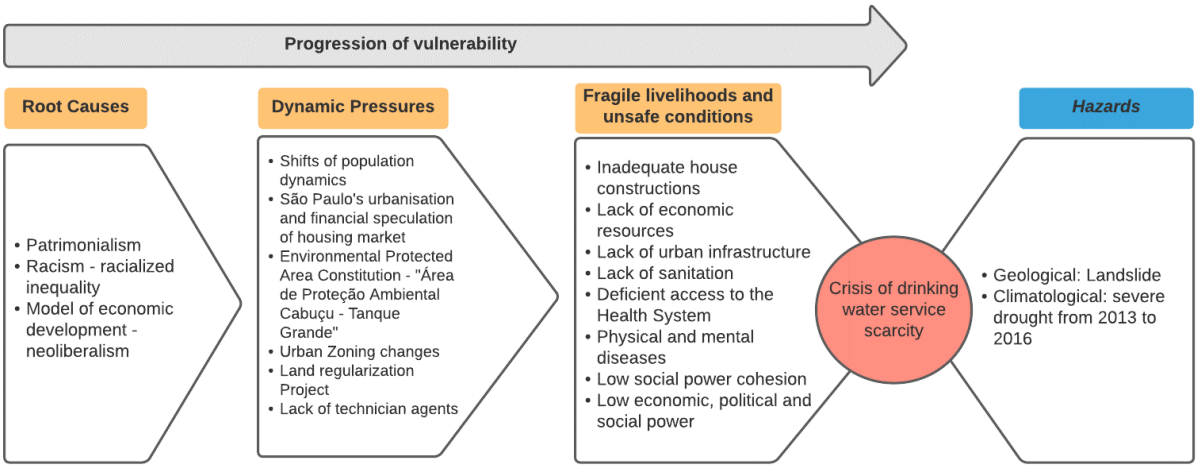

Figure 1 | PAR Model flowchart of Novo Recreio's case study.

Source: SANTOS, 2021

The diagram demonstrates that socio-economic factors boosted Novo Recreio residents' vulnerability to drought disaster conditions during 2013-2016. Beyond this, it illustrates intermittent water supply services in the territory due to historical, economic and social processes, which led to a generalised water scarcity supply, regardless of an external atypical climate factor.

Brazil's colonial period created a societal dynamic based on an exchange of favours, clientelism and patrimonialism where high society people have access to properties based on their social and economic power. In consequence, mainly poor black former enslaved people and their descendants were placed on the margin of this societal relation (ALMEIDA, 2019; JESUS, 2017; NASCIMENTO, 2016), enhancing racialised inequalities through public policies that kept those people at the bottom of society (usually, located in risky peripherical areas) (COATES; NYGREN, 2020; MARICATO, 2015; VALENCIO, 2008).

Later, the capitalist development model, followed by neoliberalist geopolitics, generated historical inequality patterns strongly related to Brazil's entrance into the international economy as an exporter of raw materials and rural and metallic commodities (PORTO; MILANEZ, 2009). The neoliberalist agenda transformed São Paulo's territorial organisation and its role in national economic policies, affecting Guarulhos as a "supporter" municipality to the São Paulo metropolis. Guarulhos contains Latin America's most prominent international airport, and it is known as an industrial region. For Adger (2006), Hogan and Marandola Jr (2006), economic globalisation contributed to increasing vulnerability, mainly in social and economic aspects, as a result of trade liberalisation as a new stage of "colonialism".

These historical processes are considered root causes for the progression of vulnerability to Novo Recreio's inhabitants because these inherited patterns have conducted societal relations and characterised political values and preferences until today. Brazil's development process may have other aspects not discussed in this study because only those listed above were identified during fieldwork and interviews.

Changes to Guarulhos's role in the development of São Paulo's metropolitan area impacted Novo Recreio's creation and further consolidation (CARVALHO, 2010). Therefore, changes in the macro politics scenario, the increase of industrialisation and the housing speculation and gentrification of São Paulo city drove the appearance of peripheral neighbourhoods to shelter migrant workers from Brazil's northeast in the 1970s and later, incentivised by the city's economic growth (OLIVEIRA, 2008). Consequently, rapid urbanisation occurred, with shifts in São Paulo's city economic and social dynamics in the financial capitalism era. As a result, the low-income classes had to move to cheaper areas, mainly on the city's border where there are landslide risks, lack of public infrastructure and generally in areas dedicated to water and forestry conservation, in São Paulo's peripheries (as Guarulhos, in SPMR) (JACOBI, 2006; MARICATO, 2006, 2015).

Novo Recreio has been created and consolidated in this context. One dweller said, "I live in a conservation area, it is not right where I live. Although, it was the place I found to live. I paid R$ 700.00, but they [the local government] can take us off at any time (dweller, 2018)". These pressure dynamics show that the São Paulo capital urbanisation induces the population movement to Guarulhos in the metropolitan region as a supplementary municipality in this territorial organisation (CARVALHO, 2010). Accordingly, the Guarulhos urbanised area has grown toward illegal settlements where the land use is made by negotiating cheap and inappropriate land.

Land ownership in Novo Recreio is still undefined juridically, although old elite families are now requesting the area's ownership. This notwithstanding, many politicians have promoted the illegal occupation of Novo Recreio through the 20th century. Racialised land occupation in Guarulhos territory has also been observed. Guarulhos has approximately 1,349,113 inhabitants (53,34% white, 45,27% black), 63% of Novo Recreio's residents identify as black and 36% as white (IBGE, 2010). De Jesus (2020) pointed out that black Brazilians continuously experience an absence of sanitation and resultant environmental health impacts.

Due to this chaotic but designed urbanisation, the Guarulhos municipal authority created the Cabuçu-Tanque Grande Protected Environment Area in 2010. However, until 2019 there was no management plan for the area that could organise territorial land use. Also, by 2011 Guarulhos was categorised as "urbanised" within an urban zoning plan, and Novo Recreio was located in a zone of recovery and sustainable use. Considering those legal aspects and landslide risks, São Paulo's Environment Public Minister prosecuted Guarulhos city hall for removing families in the risk area to restore it to its natural condition. From that, a land regularisation project started, and it resulted in the displacement of 437 families, effectively a war scenario due to the construction debris resulting from housing demolitions. The most hazardous area in Novo Recreio was in the middle of the territory, Taquara do Reino's watercourse. There was a high landslide risk because of the hill's geomorphological conditions besides the drainage watercourse.

In the end, the project was discontinued due to a flawed planning process and a review of its budget by Caixa Econômica Federal (one of Brazil's federal banks), the finance provider. The planners did not project other physical risks due to the demolition process. For example, these houses are constructed along the hill and, usually, there are different houses down the hill. Some were half-demolished because they did not see that the structure could fall out on other houses placed on the other hill face. Moreover, the demolition debris had stayed there during the study period. "It is looking like Syria. It is a war scenario when you see a house without the roof by one side" said another dweller.

The insecurity related to land property is a vulnerability indicator (HEIJMANS, 2004; WARNER; ENGEL, 2014). It represents the contradiction that even though these territories are legally protected, they are not protected by licensing and compliance agencies. Thus, environmental protection remains highly unequal across classes and ethnicities (ACSELRAD; MELLO; BEZERRA, 2009).

These dynamic changes to the territorial organisation and frequent displacement directly threaten livelihoods in Novo Recreio because they define how and when residents will have access to public services and of what quality. Thus, unequal wealth appropriation and democratic fragility are fundamental to a structural conflict in territorialisation and presenting socio-environmental specificity to hazard impacts (VALENCIO, 2008, p. 5).

Novo Recreio's population has occupied this area to escape from unaffordable high rental values. Therefore, the possibility of having their own house, illegally sold at a low price was the only way they could solve their housing problem. Furthermore, their economic condition determined the housing type, almost always built with inadequate materials that would not support a water tank, for example.

Living in a risky and protected area well known by the State did not guarantee basic urban infrastructures such as sanitation, water supply, public transportation, public health, and street lighting services. Vulnerability is associated with social disadvantages that produce poverty and simultaneously reflect and produce this poverty itself (HOGAN; MARANDOLA JR, 2006, p. 27). Thereupon, Novo Recreio's residents are directly affected in their daily life through a vicious cycle of disease provoked by waterborne diseases and arboviruses. The UBS Novo Recreio reported an increase in diarrhoea and dengue fever cases in 2015, the same period that people reserved more water in inadequate plastic tanks. Also, mental health disorders were identified due to the precarious living condition, relating psychological, subjective and symbolic dimensions to the racial stigmatisation behind the lack of sanitation for black bodies (DE JESUS, 2017).

Analysing all these aspects, the PAR model showed how the socio-economic structures of regional and local urban development have influenced the organisation of territorial space and the fragile living conditions and differentiated water supply. Accordingly, in extreme climate episodes, the disaster is already present. That is why the crise hídrica was a disaster event manufactured through root causes and dynamic socio-political pressures that culminated in a drinking water shortage.

Disaster episodes are better understood as unfolding pathological systemic changes once they are bound to the social, economic, cultural and political problems, roots that explain the transformation of vulnerability and hazard into a catastrophe (OLIVER-SMITH et al., 2017).

Many disaster managers and political decision-makers do not work with social and cultural aspects because they seem immutable or complex. However, these problems also do not disappear, resulting in three dilemmas: 1) a silence regarding the risk of disaster creation, 2) the development myth, and 3) the dominance of a security paradigm (LAVELL; MASKREY, 2014). Acknowledging the genesis of disaster on a temporal scale brings forward questions concerning intergenerational equity and ethics about the meaning of sustainable development. Blaikie et al. (1994) and Wisner (2016) ask what sustainability and development we are chasing.

The authors have clarified that the root causes are more difficult to change, but it would not be an excuse not to understand it and address dynamic public policies to reduce socio-environmental risks (BLAIKIE et al., 1994; WISNER; GAILLARD; KELMAN, 2011). Additionally, Jasanoff (2013) argues that the political practitioners should be open to thought deconstruction since, in the face of uncertainty and complex contemporary problems, only scientific information and expert speech are incapable of defeating the scepticism of people who are at different social positions with diverse social interests.

A change in view towards the water crisis as a disaster represents opportunities to improve water management and governance in São Paulo, putting climate and social problems together to change the technology-neutral paradigm to a transparent, resilient, citizen-based urban development.

5 CONCLUSION

The study demonstrated that despite the climate change dynamics and the recent drought event in SPMR, the population had already faced water scarcity. This water supply scarcity is related to a set of politics and structures that configure relations on the territory and, consequently, to the drinking water access.

In this sense, the progression of vulnerability throughout the years can impact the population financially and structurally to a point where they could not cope with or recover from a disaster. Regarding the extended drought from 2013 to 2016, the article concludes that the "crise hídrica" was a socially constructed disaster.

The lack of fresh water and the intermittent water supply discourse legitimises a precarious water supply service in Novo Recreio rooted in the rhetorical speech of the population's water waste and illegal settlement. This discourse contributes to the Novo Recreio population not perceiving the lack of water as an essential risk since lack of water supply is normalised, and risks are tiered in the face of the inequality scenario they experience in Novo Recreio.

The study found drinking water supply inequalities in Guarulhos compared to São Paulo city; it also observed impacts of the lack of drinking water supply to the Novo Recreio's inhabitants, which perpetuate unsafe health conditions that maintain a vicious cycle of disease-health-disease and the population under socio-environmental vulnerability condition.

The scenario identified in Novo Recreio is the perpetuation of a constant and dynamic cycle of socio-environmental vulnerability, as reported in the results. Intermittent water supply in Novo Recreio affects the population's physical and emotional health conditions through waterborne diseases and unsanitary territory and housing conditions, which preserve a racial stigma for its people, mostly black, who are unable to keep proper sanitation and, lastly, suffer consequences on job opportunities and sociability.

Most of the studies are searching for climate variability models to explain and/or predict weather extremes, but just a few are looking for these events' political and social impacts. Despite that, based on these discoveries, the article argues that the view on water crisis must be redirected toward a disaster view, since, by regarding it in such a manner, water stress and lack of water supply are understood in their anthropic dimension, and not as an isolated and unexpected natural event. Therefore, water scarcity is a technological risk because human relations in the territory directly affects water quality and quantity conditions.

NOTES

1 | The period of severe water scarcity in SPMR was known as "crise hídrica" (water crisis, literally translated). This article uses the Portuguese expression to emphasise the definitive meaning "The water crisis" and the additional local subtext the phrase has gained.

2 | During this research, the water and wastewater service owner in Guarulhos changed from Saae (a municipal autonomy company) to Sabesp (a State company), in 2018.

3 | In Brazil, essential sanitation services include water distribution, sewage collection and treatment, urban drainage and solid waste.

4 | In 2020, an alteration was approved to the Sanitation Federal Law 14.026/2020.

5 | Decree n. 30.840, from May 9th, 2013 – approves the Municipal Plan for Water Supply and Sanitary Sewage of the Guarulhos Municipality.

6 | IBGE census, 2010.

7 | Official data regarding socio-economic characterisation, waterborne diseases, and vectors provided by the UBS Novo Recreio and Guarulhos Health Secretary.

8 | Resnexus Project – Resiliência e vulnerabilidade quanto ao nexo urbano de alimentos, água, energia e ambiente (Fapesp process n. 15/50132-6).

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Reactive improvement of environmental policies: lessons from the Mariana and Brumadinho disasters

Aperfeiçoamentos reativos de políticas ambientais: lições dos desastres de Mariana e Brumadinho

Michelle Cristina dos Reis Braga [1]

Alberto de Freitas Castro Fonseca [2]

[1] *Master in Environmental Engineering, Researcher, Programa de Pós-Graduação em Engenharia Ambiental, Universidade Federal de Ouro Preto, Ouro Preto, Brazil*
E-mail: michelle.braga@aluno.ufop.edu.br

[2] *PhD in Sustainable Development, Researcher, Programa de Pós-Graduação em Engenharia Ambiental, Universidade Federal de Ouro Preto, Ouro Preto, Brazil*
E-mail: alberto@ufop.edu.br

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ABSTRACT

The State is not always able to proactively improve environmental policies. Eventually, policy improvements are a result of disasters that expose pre-existing problems. This situation is reflected in the state of Minas Gerais (Brazil), where, after the failures of the Fundão and B1 tailings dam, in Mariana and Brumadinho, several problems in dam safety and emergency policies were exposed. This study had a twofold objective: 1) to identify the mechanisms used by the government of Minas Gerais to improve environmental policies, and 2) to understand how the Mariana and Brumadinho's disasters affected dam safety and emergency policies. Based on semi-structured interviews and regulatory analysis, the study revealed that the state government of Minas Gerais has been predominantly reactive in controlling environmental policies. Additionally, it was observed that the disasters catalysed a learning process that culminated in potentially better dam safety policies.

Keywords: Environmental Policy Assessment. Environmental Disasters. Tailings Dams. Regulatory Learning.

RESUMO

O Estado nem sempre é capaz de aperfeiçoar políticas ambientais de maneira proativa. Eventualmente, melhorias políticas se dão em reação a desastres, que expõem, contundentemente, problemas preexistentes. Essa situação está refletida no estado de Minas Gerais (Brasil) onde, após as rupturas das barragens de rejeito de Fundão, em Mariana, e B1, em Brumadinho, ficaram expostas lacunas nas políticas de segurança e emergência de barragens. Este estudo teve dois objetivos: 1) identificar os mecanismos utilizados pelo governo de Minas Gerais para aperfeiçoar políticas ambientais; e 2)

entender como os desastres de Mariana e Brumadinho afetaram as políticas de segurança e emergência de barragens. Baseado em entrevistas semiestruturadas e análises regulatórias, o estudo revelou que o Estado tem sido predominantemente reativo no controle de políticas ambientais. Adicionalmente, foi observado que os desastres ocorridos catalisaram um processo de aprendizagem que culminou em políticas de barragens potencialmente melhores.

Palavras-chave: Avaliação de Políticas Ambientais. Desastres Ambientais. Barragens de Rejeito. Aprendizagem regulatória.

1 INTRODUCTION: DISASTERS AND ENVIRONMENTAL POLICIES

Environmental policies are imperfect and need constant monitoring and performance evaluation to support learning processes (ASSIS et al., 2012; BELLONI; SOUZA; MAGALHÃES, 2003). The improvement of environmental policies, however, does not always happen proactively. While suddenly and forcefully exposing pre-existing problems, catastrophic events often function as catalysts for change (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Many environmental disasters have driven the creation and improvement of environmental public policies (HOGAN, 2007; POTT; ESTRELA, 2017). In London, four years after the "Great Smog" of 1952, the Clean Air Act was created, thus establishing measures to control pollution caused by burning coal (WALLER, 1971). In 1956, in Japan, there was a significant episode of mercury contamination in the Minamata Bay that stimulated discussions on the use of chemical compounds and their effects on flora and fauna, thus leading to the ban of DDT and to an environmental movement that would gain strength in the following decade (HOGAN, 2007).

In 1977, toxic substances, including dioxin, were released due to an explosion in the chemical industry in Seveso, Italy (HOGAN, 2007). Years after this disaster, the Seveso Directive was regulated to prevent accidents involving dangerous substances and limit their adverse effects on the environment and society (POTT; ESTRELA, 2017). Still, in the late 1970s, hazardous waste disposal and human occupation in the Love Canal (USA) unfolded into reproductive problems among women and into high levels of chemical contaminants in the soil and air. This led to the approval of the Comprehensive Environmental Response, Compensation and Liability Act (Superfund), which gave the Environmental Protection Agency (EPA) the authority to respond to releases of hazardous substances that could endanger public health or the environment (ENVIRONMENTAL PROTECTION AGENCY, 2018; HOGAN, 2007).

An accident in the Three Mile Island nuclear power plant in Pennsylvania (USA) in 1979 triggered debates around the use of atomic energy. Years later, in 1986, the explosion of a nuclear reactor in Chernobyl (Ukraine) increased environmental awareness in Europe and promoted favourable conditions for the implementation of environmental policies (FREY, 2000). In the 1980s, there was also a leak of toxic gases from a pesticide industry in Bhopal (India), which resulted in the approval of the Convention 174 of the International Labor Organization (ILO), aimed at preventing industrial accidents and reducing their risks and consequences (POTT; ESTRELA, 2017).

A similar phenomenon of reactive improvement of environmental policies recently occurred in Minas Gerais, Brazil, after the failures of the Fundão tailings dam failures, in Mariana, in 2015 and of the B1 tailings dam Brumadinho in 2019. These disasters, in addition to killing hundreds of people, caused severe biophysical and socioeconomic damage. The magnitude of these damages shed light on the many flaws and limitations of existing dam safety and emergency policies (MILANEZ et al., 2019). At the state and federal levels, various legal and regulatory changes were triggered by the failures of these dams. However, the political and institutional learning of these failures remains fragmented and marginally explored in the literature.

This article sought to answer the following questions: How does the Minas Gerais state government monitor and improve its environmental policies? How did the dam failures affect the State's institutional-

regulatory learning? More specifically, the study had a twofold objective: 1) to identify the mechanisms used by the government of Minas Gerais to improve environmental policies, and 2) to understand how the Mariana and Brumadinho disasters affected dam safety and emergency policies.

2 POST-DISASTER POLITICAL AND INSTITUTIONAL LEARNINGS

Catastrophic events can reveal organisational dysfunctions and stimulate reflections regarding the analysis, diagnosis and prevention capacity of the actors involved in policy-making, thus opening up opportunities for dialogue and collaborative learning between groups and organisations (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015; LLORY; MONTMAYEUL, 2014). Disasters, in particular, have a considerable level of leverage to trigger change, as they attract the attention of managers, regulators and other stakeholders, generating significant pressure to investigate, understand and implement improvements, including in the regulatory system (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

However, the post-disaster learning process is not trivial: several technical, organisational or cultural obstacles must be overcome (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015). Learning involves identifying deficiencies and implementing changes at various levels of the system where different actors are involved. Through the establishment of laws, governments make priorities explicit and define limits, guiding or restricting the behaviour of public agencies and entrepreneurs. Subsequently, these laws are interpreted and regulated. To be operational, these regulations have to adapt to the particular contexts of each project, taking into account the existing resources and procedures. Finally, at the technical-operational level, legal requirements are put into practice (RASMUSSEN, 1997). In addition to these interactions, the different actors are influenced by "external pressure" during the learning process, whether political, economic or technological, as illustrated in Figure 1.

2.2 WHEAT AND DERIVATIVES SECTOR

The wheat and derivatives segment comprises the manufacture of wheat flour, wheat milling, the manufacture of semolina and wheat bran, the manufacture of other wheat derivatives and the manufacture of flour and mixed pasta (powder) and prepared for the manufacture of bread, cakes, cookies, etc. (ECONODATA, 2020).

According to this database, this segment consists of 798 companies distributed between 26 Brazilian states, as shown in Figure 1.

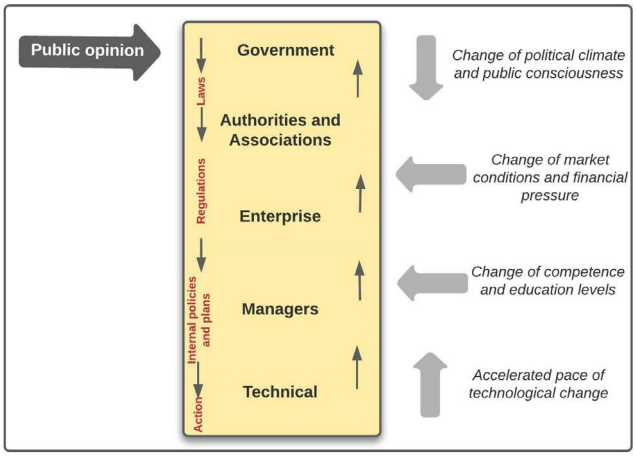

Figure 1 | Interactions between actors in the process of creating and improving policies, laws and regulations

Source: Adapted from RASMUSSEN (1997)

Post-disaster learning encompasses the steps of reporting, analysing, planning, implementing and monitoring effectiveness (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015). Some organisational or cultural issues, however, may impair learning, such as the absence or poor quality of information and records; the absence of statistical and trend analysis to support decisions on future investments or organisational changes; unfamiliarity of root causes; restriction of human and financial resources; among others (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

In many cases, political-institutional lessons learned in the post-disaster context are translated into laws and regulations. Which, by itself, does not guarantee the effectiveness of the requirements. For Barros et al. (2012), legal requirements are only efficient if they are well applied, fulfilled and assimilated by social agents. These authors further state that:

> Having good laws is the first and most crucial step, but it's not enough. The standard is just a starting point. For its effectiveness, it is necessary to establish conditions that make its application feasible, such as the hiring of specialised technicians, adequate infrastructure and financial resources to carry out the work, in addition to an educated public aware of environmental issues (BARROS et al., 2012, p.173).

Furthermore, understanding the causes of a disaster, by itself, does not contribute to political-institutional learning. The behavioural change of organisations, whether they are private enterprises or public bodies, the constant search for technical knowledge and the critical sense of the interested parties are some of the preponderant factors for learning from disasters. Effective actions are, therefore, crucial for learning (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Finally, it should be noted that limited learning leads to the recurrence of disasters. The failure of the Fundão dam in 2015 exemplifies this issue. Despite the several changes in the instruments for managing the safety and emergency plans of dams after the event, there was the second disaster in Brumadinho and an even more catastrophic one in terms of loss of human lives. This situation indicates that the analyses of the disasters were superficial, being limited to the identification of direct causes, such as technical and human flaws. Root causes, which are generally organisational, were not adequately remedied (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

A technical study was written by Poemas (2015), published shortly after the Mariana disaster, indicated limitations in the institutional learning of the environmental agencies and dam inspectors at the state and federal levels. Such institutions were going through institutional capacity problems, such as lack of personnel, equipment and resources to promote more effective and efficient inspections. Even after the disasters, the National Mining Agency (ANM) continues to face budget restrictions and delays in the availability of resources, which hinder the proper development of planned actions (AGÊNCIA NACIONAL DE MINERAÇÃO, 2020). The failures of the tailings dams in Minas Gerais offer, therefore, a fertile ground for evaluating reactive improvements in environmental policies

3 EVOLUTION OF TAILINGS DAM'S SAFETY AND EMERGENCY POLICIES AT THE STATE AND FEDERAL LEVELS

The first dams designed to contain tailings from mining activities were built at the beginning of the 20th century. Previously, tailings were directly discarded into the environment, as their impacts were considered insignificant or acceptable by governments and society (ÁVILA, 2012). Tailings dams are complex structures that demand strict regulations and adequate management to reduce their many risks. In addition to the inherent hazards to the construction methods, tailings properties may change over time, and project changes may jeopardise initial safety assumptions (INTERNATIONAL COMMISSION ON LARGE DAMS, 2001).

After the 1960s, guidelines for dam safety management were established in Brazil by creating an institution currently known as the Brazilian Dam Committee (whose *acronym in Portuguese* is CBDB). In the 1980s and 1990s, CBDB published books on Brazilian dams, safety procedures and guidelines for inspection, auscultation and instrumentation (MELLO; PIASENTIN, 2011).

The Federal Ministry of Mines and Energy, in the late 1980s, created a workgroup to standardise preventive and maintenance procedures aimed at dam safety. This group prepared a report dealing with monitoring and instrumentation, the frequency of inspection, general guidelines to be followed in accidents, and the definition of responsibilities for carrying out the actions (MELLO; PIASENTIN, 2011).

In 1996, CBDB drafted an Ordinance containing guidelines for assessing the safety of dams and proposing the creation of the National Dam Safety Council. However, this proposal was not pursued by the government. In 1999, CBDB prepared the Basic Guide for Dam Safety (MELLO; PIASENTIN, 2011).

In 2002, the Dam Management Program started in Minas Gerais, indicating criteria for dam classification, minimum requirements to be included in the management system, and considered in environmental studies related to the main stages of dam's licensing procedures (MINAS GERAIS, 2002).

The pioneering role of the government of Minas Gerais is primarily a result of disruptive events that occurred previously, in 1986 and 2001. During the 2000s, guidelines were therefore established in Minas Gerais to support technical security audits and the mandatory submission of the Declaration of Stability Condition (DCE) of the dams to the environmental agency.

More vital legislation on dam safety came with the sanction of Law nº. 12334/2010, which established the National Policy for Dam Safety (PNSB). The bill that culminated in this law was drafted reactively after dam failures in 2001 and 2003 in Minas Gerais, reinforcing the need to approve specific legislation on this subject (ESTANISLAU; BELLEZZIA, 2017; MELLO; PIASENTIN, 2011). Furthermore, many problems were recognised, including latent vulnerabilities in projects and issues in the construction and operation of existing structures (AGÊNCIA NACIONAL DE MINERAÇÃO, 2018).

Before the PNSB, there were voluntary, isolated initiatives by some entrepreneurs who were trying to implement in their Brazilian facilities the same operational and safety standards adopted internationally in their dams (AGÊNCIA NACIONAL DE MINERAÇÃO, 2018). There was a general lack of articulation between competent authorities in the public sphere, which dealt separately with the many issues related to dams (ZONTA; TROCATE, 2016). In this sense, the PNSB was an attempt to expand government control over dams based on inspections and compilation of information, thus allowing for improved dam safety management (BRASIL, 2010).

One of PNSB's principles is that developers are legally responsible for the dam's safety, thus being required to implement actions to guarantee it, including effective management systems and compliance with the regulations. In the case of mining tailings dams, government safety inspections are the responsibility of the National Mining Agency (ANM). However, environmental agencies can carry other inspections that make up Brazil's National System of Environmental Institutions (whose acronym in Portuguese is Sisnama).

ANM, the national mining agency, established regulations for managing the safety and emergency of mining dams in 2012 and 2013. But, after the Fundão dam failure, these regulations were unified and further enhanced to incorporate the learning outcomes of this disaster (BRASIL, 2012, 2013, 2017).

After the Brumadinho disaster, a proposed bill culminated in Law 14066/2020, which changed the previous PNSB, incorporating new requirements. There were intense regulatory changes at the state and federal levels, leading to various new regulations (BRASIL, 2020).

In Minas Gerais, after the collapse of the B1 dam, the State Policy for Dam Safety (Pesb) was established through Law nº. 23291/2019, being applied to dams designed to contain and/or dispose of mining tailings, residues, water or other liquids that are associated with industrial or mining activities, being more restrictive than the PNSB (MINAS GERAIS, 2019).

The Pesb established some principles, such as the prevalence of the most protective norm for the environment and communities, as well as the prioritisation of actions of prevention, inspection and monitoring by state environmental agencies and entities. Furthermore, it determined that they should articulate with the bodies and entities responsible for the PNSB in information sharing and inspections. The requirements of the Pesb were regulated in specific normative acts, as shown in Figure 2.

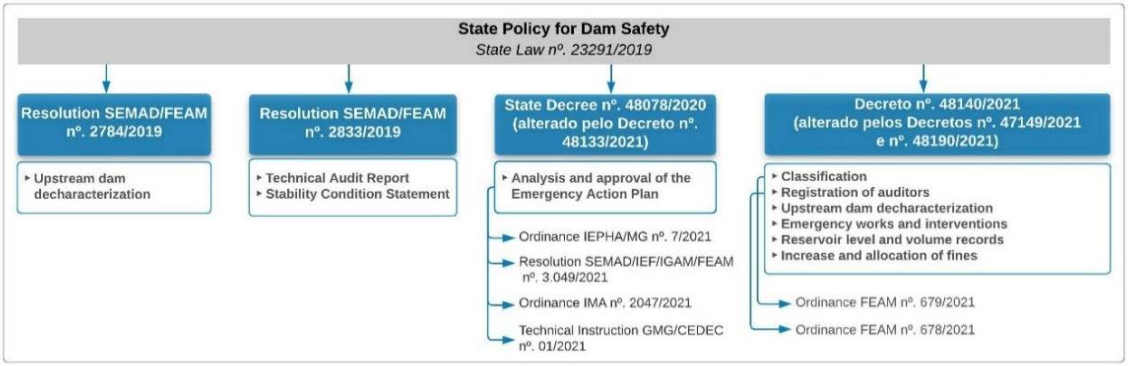

Figure 2 | State Dam Safety Policy and its Main Regulations

Source: Authors (2021)

Given the context mentioned above, this article will discuss the roles of Mariana and Brumadinho in promoting regulatory learning.

4 METHODS

This study addressed the particular context of Minas Gerais, which is a leading Brazilian state in mineral production with decades of experience in implementing different types of environmental policies, including policies aimed at the safety and emergency management of dams. Two qualitative data collection and analysis approaches were adopted in this research: semi-structured interviews and content analysis.

In semi-structured interviews, the researcher asks predetermined but open questions to obtain greater depth in answers. Thus, there is more control over the topics investigated than in unstructured interviews, and there is no fixed interval of responses for each question (AYRES, 2008). We opted for this methodological approach to capture deeper and contextual elements in respondents' answers.

The interviews were carried out with eight professionals who work in different departments of the State Government Environmental System (whose Portuguese acronym is Sisema). The respondents were intentionally chosen because of their knowledge and experience with other environmental policy instruments. The interviews were all telephone-based and lasted an average of 45 minutes (between 30 and 60 minutes). They were recorded using a smartphone application and later transcribed and analysed. All respondents were aware of the purpose of the study and signed an Informed Consent Form previously approved by the Research Ethics Committee of the Federal University of Ouro Preto. The participants were coded to preserve their identities (P1 to P8). Table 1 presents the details of the methodology used in the interviews.

Table 1 | Methodology used in semi-structured interviews

Number of respondents	*Eight (identified as P1 to P8)*
Date of the interviews	January/2019, February/2019 and March/2020
Respondents' profile	Managers and analysts from the State Secretary for the Environment and Sustainable Development (Semad), State Forest Institute (IEF), Institute for Water Management (Igam) and State Environment Foundation (Feam), responsible for the implementation and control of environmental policy instruments
Main interview content	Respondent's profile and experience, performance controls (administrative and territorial), challenges and priorities in improving environmental policy instruments
Types of questions	Open
Questionnaire type	Semi-structured
Communication media	Phone calls (recorded through smartphone app)
Data analysis	Transcription, coding, and analysis of patterns and relevant content

Source: : Authors (2021)

Through interviews, we sought to investigate the study's first objective, namely, how the state government monitors and evaluates the performance of environmental policies. More specifically, the following themes were explored: which technologies, tools or indicators are used, the main challenges faced, and the perception of professionals about the effectiveness of environmental policies in the state. In the context of this research, effectiveness is understood as the achievement of the objective proposed by a policy, be it the change or maintenance of specific environmental conditions. The primary purpose of the interviews was to obtain a general overview of policy learning and control at the state government. Specificities of one or another environmental policy instrument were not further explored.

The content analysis of policies, laws and regulations related to dam safety and emergency management required careful evaluations of textual material (KRIPPENDORFF, 2004). This method included categorising qualitative textual data into groups of similar entities to identify consistent patterns and relationships between variables or themes (JULIEN, 2008). This method proved to be suitable for analysing the temporal evolution of legal instruments aimed at tailings dams.

This study evaluated the primary laws and regulations enacted until 31 May 2021 at the state level, in Minas Gerais, and at the federal level. A matrix was used to organise the legal and regulatory changes that took place after the failures. Based on the identified changes, we discuss the learning process triggered by the disasters

5 RESULTS AND DISCUSSIONS

5.1 EVALUATION OF THE PERFORMANCE AND EFFECTIVENESS OF ENVIRONMENTAL POLICIES IN MINAS GERAIS

The interviewees pointed out a series of issues that hinder or prevent the control of the performance of environmental policies in Minas Gerais: the lack of systematic monitoring of the improvement of environmental quality; the absence of constant monitoring of environmental data; incompatible systems, which are restricted to administrative controls and even the inexistence of methods, among others, were reported.

Participant P1, who held several managerial positions related to protected areas and conservation policies, stated that *"there are some tools that we use that bring some indicators, but they are of little significance [...] there is no such systematic monitoring in connection with the environmental quality of the territory*". Participant P2, who has extensive managerial experience in inspection and administrative sanctions, reported that he uses a basic system that cannot verify the instrument's effectiveness in terms of environmental quality outcomes.

Respondents cited the importance of using systems to manage environmental policy instruments and control their performance. However, several problems were reported in the existing systems, such as low reliability, modernisation, and customisation. Interviewee P6, who worked in the management of water resources and sustainable development policies, stated: "[...] *today our database is very inconsistent because the old system did not have control over the consistency of the data released by the analysts*". The inspection mentioned above and sanctions manager, P2, reported that "[...] *the system does have some condition to generate some reports, but we do not use it daily*". And he added: *"we need a better system, that's for sure [...] there's even a reliability problem in it too."*

The precarious systematisation and availability of data reported by the research participants is not a recent issue in environmental agencies in Minas Gerais. Ribeiro (2005) detected in his study that, in many cases, data were available in these institutions. Still, they were not presented in an organised and systematic way, demanding further collection and reporting. This situation was also observed by Assis et al. (2012) in an analysis of Brazilian environmental policies.

The scarcity of information about the performance of environmental policies coordinated by the state government makes it difficult for public agencies to implement and improve policies, as well as prioritise efforts, leading to institutional disparities: while some instruments have staff and resources for its execution, others receive little attention and are underutilised.

Regarding the effectiveness of environmental policy instruments, there were different perceptions among interviewees. This was already expected since other devices have different characteristics, effects, levels of regulation and institutional maturity. It was reported by participant P4, who has extensive experience in forest and vegetation removal approvals and management, that when there is a tangle of norms related to a particular environmental policy instrument, it adds complexity, making it impractical to manage effectiveness.

Participants P2, P3, P5 and P7 were of the general opinion that the state environmental policies are effective, arguing that they contribute to the control of pollution and environmental degradation, act as barriers to the irregular occupation of natural areas or promote environmental awareness using penalties and sanctions. In other words, they see effectiveness in the mere existence of environmental policies. This perception that the absence of policies would aggravate environmental quality corroborates the view of Moura (2016), who stated:

> [...] there is a perception that many environmental problems have been worsening in the country, while the instruments devised for environmental policy have not advanced – at a sufficient pace and intensity – in the changes necessary for better management of the environment. Even so, there is no doubt that the deterioration of environmental quality in this period would have been more serious if these regulatory, economic, voluntary or informational tools had not been used to address environmental problems (MOURA, 2016, p. 139 -140).

However, it is noteworthy that "contributing to a goal" and "achieving a goal" are different issues, as assumed in the concept of effectiveness. The limitation of human resources, low investments in the technical qualification of the teams, insufficiency or poor distribution of financial resources, decisions distorted by political influences, lack of articulation between environmental agencies, lack of clear priorities and a focus on document analysis to the detriment of inspection were pointed out by the

several interviewees as the main bottlenecks for the effectiveness of environmental policy instruments. For example, participants P1, P2 and P3 externalised during the interviews that:

> (it is not effective) due to lack of resources and resources include people and financial resources as well. So, there is a lack of money, and we waste a lot of time trying to resolve things and, in the end, we always come up against some government decision, lack of resources, a new year, a state bureaucracy [...] (P1).
>
> [...] the environment demands many different focuses, there is licensing, there is inspection, so we stay in a 'pot' [sic], waiting for many other priorities to be met (P2).
>
> [...] the money is used for many other things, except for its core activity, for its effective purpose [...] the money that is collected is not applied as it should be (P3).

For Moura (2016), institutional structures and participation processes involving social and economic agents determine the quality of environmental policies. For this author, the population's involvement in the elaboration, execution and evaluation of policies is one of the pillars of success. In this regard, the interviewees mentioned that public participation in environmental policies occurs through consultations, meetings, hearings, technical chambers and councils. Participatory management was mentioned in the interviews as an essential step towards the effectiveness of the instruments, which corroborates Assis *et al.* (2012, p.18), who stated: "It is essential that different actors, who may have conflicting visions and objectives, be incorporated into the assessment".

Despite the recognition of the importance of civil society participation in the formulation of effective environmental public policies, there are structural issues in Minas Gerais that lead to the pseudo-social involvement in public hearings and State Council for Environmental Policy (Copam) chambers (CARNEIRO, 2005; MOURA, 2016; SALHEB et al., 2009).

The interviews demonstrated weak preparation and articulation among state environmental agencies when evaluating the performance of policies, thus reinforcing the obscure "cause-and-effect relationship" between policies and environmental quality on the ground. The lack of priorities and evidence of effectiveness hinders the improvement of policies, as several relevant aspects, such as the management capacity of environmental agencies and entities, are not considered in decision-making. Difficulties and challenges in evaluating the performance of environmental policies pointed out by the interviewees were also identified in the literature.

It was observed that in Minas Gerais, difficulties in measuring progress in environmental policies result from a lack of structured assessment mechanisms. For Moura (2016), without these mechanisms, notions of effectiveness will remain imprecise or partial.

The existence of a continuous learning system was not evidenced in the interviews. This situation hinders the preventive action of the State. The occurrence of disasters in Minas Gerais is likely a symptom of the inefficiency of the policy control. Unwanted events become catalysts for a learning process that reactively seeks improvements based on the causes and consequences of what happened.

However, the difficulties presented by the interviewees cannot represent an impediment to the performance evaluation of environmental policies. They must reinforce the search for knowledge and investments so that the evaluation is helpful to direct policies, promoting improvements and the efficient allocation of public resources based on participatory and democratic mechanisms.

5.2 POST-DISASTER LEARNING IN MINAS GERAIS: ANALYSIS OF LEGISLATIVE CHANGES ON DAM SAFETY AND EMERGENCY MANAGEMENT

The second part of this study focused more specifically on policy changes aimed at dam safety and emergency management, which reflect a reaction to the Mariana and Brumadinho disasters. This part sought to understand the details of the changes and the 'bulk' of the lessons learned. This part, however, was not based on interviews but, as previously explained in the methods section, on content analysis of laws and regulations. As shown in Table 2, an intense legislative and regulatory activity was identified after the Mariana disaster and, above all, after the Brumadinho disaster.

Table 2 | Laws and regulations aimed at the safety and emergency management of tailings dams

STATE LEGISLATION	
Mariana's pre-disaster	
Resolution Semad nº. 99/2002	January 29, 2002
Normative Deliberation Copam nº. 62/2002	December 17, 2002
Normative Deliberation Copam nº. 74/2004	September 9, 2004
Normative Deliberation Copam nº. 87/2005	June 17, 2005
Normative Deliberation Copam nº. 124/2008	October 9, 2008
State Decree nº. 44.844/2008	June 25, 2008
Mariana's post-disaster	
State Decree n°. 46.892/2015	November 20, 2015
State Law nº. 21.972/2016	January 21, 2016
State Decree n°. 46.993/2016	May 2, 2016
Normative Deliberation Copam nº. 210/2016	September 21, 2016
Normative Deliberation Copam nº. 217/2017	December 06, 2017
Normative Deliberation Copam nº. 228/2018	November 28, 2018
Brumadinho's post-disaster	
Resolution Semad nº. 2.762/2019	January 29, 2019
Resolution Semad/Feam nº. 2.765/2019	January 30, 2019
State Law nº. 23.291/2019	February 25, 2019
Resolution Semad/Feam nº. 2.784/2019	March 21, 2019
Official Notice GMG/Cedec nº. 02/2019	June 25, 2019
Resolution Semad/Feam nº. 2.833/2019	August 26, 2019
State Decree nº. 47.739/2019	October 18, 2019
State Decree nº. 48.078/2020	November 5, 2020
State Decree nº. 48.140/2021	February 25, 2021
Resolution Semad/Feam/IEF/Igam nº. 3.049/2021	March 2, 2021
Ordinance IMA nº. 2047/2021	March 31, 2021
Ordinance Iepha/MG nº. 7/2021	April 9, 2021
Ordinance Feam nº. 678/2021	May 6, 2021
Ordinance Feam nº. 679/2021	May 6, 2021
Technical Instruction GMG/Cedec nº. 01/2021	May 21, 2021

FEDERAL LEGISLATION	
Mariana's pre-disaster	
Federal Law nº. 12.334/2010	September 20, 2010
Ordinance DNPM nº. 416/2012	September 03, 2012
Ordinance DNPM nº. 526/2013	December 09, 2013
Mariana's post-disaster	
Ordinance DNPM nº. 14/2016	January 15, 2016
Ordinance Secretaria Nacional de Proteção e Defesa Civil nº. 187/2016	October 26, 2016
Ordinance DNPM nº. 70.389/2017	May 17, 2017
Brumadinho's post-disaster	
Resolution of the Ministerial Council for the Oversight of Disaster Responses nº. 1/2019	January 28, 2019
Resolution of the Ministerial Council for the Oversight of Disaster Responses nº. 2/2019	January 28, 2019
Resolution ANM n°. 4/2019	February 15, 2019
Resolution ANM n°. 13/2019	August 8, 2019
Resolution ANM n° 32/2020	May 11, 2020
Resolution ANM n° 40/2020	July 6, 2020
Federal Law nº. 14.066/2020	September 30, 2020
Resolution ANM nº. 51/2020	December 24, 2020
Resolution ANM nº. 56/2021	January 28, 2021

Source: : Authors (2021)

The study identified that there was, particularly in Minas Gerais, an incremental learning process. Years before the publication of the PNSB, the State already had a dam classification system and required documents and data on the dam structures during the environmental licensing process. The state government was the precursor of several changes, later implemented at the federal level for mining dams and other dams. Table 3 exemplifies the pioneering role of Minas Gerais.

Table 3 | Examples of pioneering dam safety regulations in Minas Gerais

Description	*State Level*	*Federal Level (Mining dams and/or other types)*
Dam Registration	Resolution Semad nº. 99/2002	Federal Law nº. 12.334/2010
Determines the registration of professionals who attest to the stability of dams	State Law nº. 23.291/2019	Federal Law nº. 14.066/2020
Determines measures to rescue people, animals and cultural heritage, mitigate environmental impacts and ensure water supply	State Law nº. 23.291/2019	Federal Law nº. 14.066/2020
Determines upstream dam 'de-characterization' (decommissioning)	Resolution Semad/Feam n° 2.765/2019	Resolution ANM nº. 4/2019
Determines the analysis and approval of Emergency Action Plana	State Decree nº. 48.078/2020	Resolution ANM nº. 51/2020
Establishes guidelines for the elaboration of flood studies	Official Notice GMG/ Cedec nº. 02/2019	Resolution ANM nº. 32/2020
Determines public hearings to present the Emergency Action Plan	State Law nº. 23.291/2019	Federal Law nº. 14.066/2020

Source: Authors (2021)

It was found that some learnings catalysed by the failure of the Fundão dam were materialised only after the collapse of the B1 dam. An example is the implementation of the State Policy for Dam Safety (Pesb), which resulted from the Popular Initiative Law Project called "Sea of Mud Never Again", proposed in July 2016. After the collapse of the B1 dam, the urgency and relevance of the law mentioned above was more clearly perceived, thus leading to its sanction one month after the dam break.

Therefore, it was "necessary" the occurrence of two disasters for the implementation of some determinations at the state level, such as: detailing of flood studies' methodology, mandatory three-phase environmental licensing for dam construction and change, the requirement of a guarantee to ensure socio-environmental recovery, public hearings to discuss the conceptual design of dams, environmental licenses conditioned to the approval of Emergency Action Plans (by various sector entities), requirement for the prioritisation of disposal alternatives that minimise social and environmental risks and promote the dewatering of tailings and residues, creation of Dam Management Information System (Sigibar) and compatibility of the state and federal dam classification systems.

At the federal level, the ANM, mainly after the failure of the B1 dam, established new requirements related to dam safety and emergency management. Furthermore, a cooperation agreement was signed with the Organization for Economic Cooperation and Development (OECD) to review the regulation and governance of the mineral sector. The ANM aims to identify regulatory barriers that may hinder the implementation of public policies and correct inefficiencies in the mineral sector based on the best global practices from countries such as Canada, Australia and the United States (AGÊNCIA NACIONAL DE MINERAÇÃO, 2020). In its preliminary report, the OECD highlighted the need to optimise inspection activities, to reduce the risks of accidents (AGÊNCIA NACIONAL DE MINERAÇÃO, 2021).

A large part of the effort of public and private institutions has been focused on improving emergency management by dealing with procedures that can avoid failures or minimise damage resulting from them, especially loss of life. It is worth mentioning that, in response to the Brumadinho disaster, the Global Industry Standard on Tailings Management was established, which, based on the lessons learned from recent failures and existing good practices, set out global guidelines for the safe management of dams (UNITED NATIONS ENVIRONMENT PROGRAMME; INTERNATIONAL COUNCIL ON MINING AND METALS; PRINCIPLES FOR RESPONSIBLE INVESTMENT, 2020). While the mining industry's interests prevailed in its preparation, this Standard defined auditable principles and requirements that emphasise the relevance of engagement and communication with stakeholders throughout the entire life cycle of dams (HOPKINS; KEMP, 2021).

The analysis carried out here suggests that changes in legal requirements are not enough to prevent new disasters. It is necessary that developers comply with legal requirements and that the supervisory and regulatory bodies have sufficient financial and human resources to monitor compliance with their determinations. If laws and regulations disregard the capacity of supervisory bodies or licensing entities, the effectiveness of existing policies is compromised. Regulatory changes in the context of developing economies like Brazil must be accompanied by capacity-building and intuitional strengthening.

6 FINAL REMARKS

The proactive performance assessment of environmental policies enables a better understanding of policies' actual implications and opportunities for improvement, thus legitimising political changes and helping governments to make more scientific and evidence-based decisions, which can, ultimately, contribute to the enhanced distribution and use of resources (ASSIS *et al.*, 2012; BELLONI; SOUZA; MAGALHÃES, 2003; CRABBE; LEROY, 2008; MICKWITZ, 2006).

In Brazil, however, the socio-environmental effects of policies are not constantly monitored, making their assessment and, consequently, political-institutional learning difficult. Specifically, in Minas Gerais,

interviewees suggested that state environmental agencies still have weak control and articulation in assessing policies. Environmental disasters become a 'natural' catalyst of policy improvement in this context, as reflected in tailings dams' recent legislative and regulatory changes.

The failures of the Fundão and B1 dams stimulated discussions about the effectiveness of dam safety and emergency policies, and therefore accelerated a learning process. Regrettably, however, the Fundão disaster was not enough. It was "necessary" for the second disaster of Brumadinho to simulate more meaningful learning (MILANEZ, 2021).

This article identified several institutional challenges faced by the government of Minas Gerais that hinder or prevent the control of environmental policies and, consequently, the prioritisation of correction and preventive measures. In the present study, empirical evidence was obtained about the capacity of public institutions, and it was found that the perception of professionals working in state environmental agencies corroborates previous studies.

When it comes to dam safety and emergency management, the assessment carried out revealed that the changes that took place were not mere coincidences: the vast majority of, if not all, regulatory changes are directly related to the causes or consequences of both disasters. Advances in dam safety could occur due to studies, methodologies and good practices disseminated among professionals, but not in the speed and intensity observed here.

The identified challenges of policy effectiveness evaluations are mainly related to mismatches between laws' intended objectives and their actual implementation, budget cuts, lack of personnel and technical resources, and lack of knowledge or disregard for the benefits of policies at different levels of management. It is, therefore necessary, among other aspects, to strengthen the institutional capacity of government agencies.

Mariana and Brumadinho demonstrated no "zero risk" for tailings dams, no matter how good the engineering projects and legal requirements safeguard these structures. Developers must comply with legal requirements, and the supervisory and regulatory bodies need sufficient human and financial resources to monitor compliance with their determinations.

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Aperfeiçoamentos reativos de políticas ambientais: lições dos desastres de Mariana e Brumadinho

Reactive improvements of environmental policies: lessons from the Mariana and Brumadinho disasters

Michelle Cristina dos Reis Braga [1]

Alberto de Freitas Castro Fonseca [2]

[1] *Mestrado em Engenharia Ambiental, Pesquisadora, Programa de Pós-Graduação em Engenharia Ambiental, Universidade Federal de Ouro Preto, Ouro Preto, MG, Brasil*

[2] *Doutorado em Desenvolvimento Sustentável, Pesquisador, Programa de Pós-Graduação em Engenharia Ambiental, Universidade Federal de Ouro Preto, Ouro Preto, MG, Brasil*

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ARTICLE – VARIA

RESUMO

O Estado nem sempre é capaz de aperfeiçoar políticas ambientais de maneira proativa. Eventualmente, melhorias políticas se dão em reação a desastres, que expõem, contundentemente, problemas preexistentes. Essa situação está refletida no estado de Minas Gerais (Brasil) onde, após as rupturas das barragens de rejeito de Fundão, em Mariana, e B1, em Brumadinho, ficaram expostas lacunas nas políticas de segurança de barragens. Este estudo teve dois objetivos: 1) identificar os mecanismos utilizados pelo governo de Minas Gerais para aperfeiçoar políticas ambientais; e 2) entender como os desastres de Mariana e Brumadinho afetaram as políticas de segurança de barragens. Baseado em entrevistas semiestruturadas e análises regulatórias, o estudo revelou que o Estado tem sido predominantemente reativo no controle de políticas ambientais. Adicionalmente, foi observado que os desastres ocorridos catalisaram um processo de aprendizagem que culminou em políticas de barragens potencialmente melhores.

Palavras-chave: Avaliação de Políticas Ambientais. Desastres Ambientais. Barragens de Rejeito. Aprendizagem regulatória.

ABSTRACT

The State is not always able to proactively improve environmental policies. Eventually, policy improvements are made in response to disasters, which sharply expose pre-existing problems. This situation is reflected in the state of Minas Gerais (Brazil) where, after the failure of Fundão tailing dam, in Mariana, and B1 tailing dam in Brumadinho, gaps in dam safety and emergency policies were exposed. This study had two objectives: 1) to identify the mechanisms used by the government of Minas Gerais to improve environmental policies; and 2) understand how Mariana and Brumadinho

disasters affected dam safety and emergency policies. Based on semi-structured interviews and regulatory analysis, the study revealed that the state has been predominantly reactive in controlling environmental policies. Additionally, it was observed that the disasters that occurred catalyzed a learning process that culminated in potentially better dam policies.

Keywords: *Environmental Policy Assessment. Environmental Disasters. Tailings Dams. Regulatory Learning.*

1 INTRODUÇÃO: DESASTRES E POLÍTICAS AMBIENTAIS

Políticas ambientais são imperfeitas e carecem de monitoramento e avaliação de desempenho para verificar seus efeitos e subsidiar processos de aprendizagem (ASSIS *et al*., 2012; BELLONI; SOUZA; MAGALHÃES, 2003). O aperfeiçoamento de políticas ambientais, entretanto, nem sempre se dá de maneira proativa; eventos catastróficos são, frequentemente, os principais catalisadores de mudanças, pois expõem, de forma súbita e contundente, problemas preexistentes (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Diversos desastres ambientais impulsionaram a criação e aperfeiçoamento de políticas públicas ambientais nas últimas décadas (HOGAN, 2007; POTT; ESTRELA, 2017). Em Londres, quatro anos após o desastre conhecido como "A névoa matadora", ocorrido em 1952, houve a criação da Lei do Ar Limpo, onde foram estabelecidas medidas de controle da poluição causada pela queima de carvão (WALLER, 1971). Em 1956, no Japão, houve a contaminação por mercúrio na Baía de Minamata. As discussões acerca do uso de compostos químicos e seus efeitos na flora e fauna levaram à proibição do uso do defensivo agrícola DDT e iniciou um movimento ambientalista que tomaria força na década seguinte (HOGAN, 2007).

Em 1977, houve a liberação de substâncias tóxicas, entre elas a dioxina, devido a uma explosão em uma indústria química em Seveso na Itália (HOGAN, 2007). Anos após o desastre, houve a regulamentação da Diretiva de Seveso, cujo objetivo era prevenir acidentes envolvendo substâncias perigosas e limitar suas consequências para o ser humano e o meio ambiente (POTT; ESTRELA, 2017).

Ainda no fim da década de 1970, houve a disposição de resíduos industriais e, posteriormente, a ocupação humana no Love Canal (EUA). Devido à presença de resíduos tóxicos, foram constatados problemas reprodutivos entre as mulheres e altos níveis de contaminantes químicos no solo e no ar. O ocorrido levou à aprovação da Lei de Resposta, Compensação e Responsabilidade Ambiental Abrangente (*Superfund*), que forneceu à *Environmental Protection Agency* (EPA) a autoridade de responder às liberações de substâncias perigosas que podem colocar em risco a saúde pública ou o meio ambiente (ENVIRONMENTAL PROTECTION AGENCY, 2018; HOGAN, 2007).

Um acidente na usina nuclear de *Three Mile Island,* na Pensilvânia (EUA), em 1979, levantou a discussão em torno do uso da energia nuclear. Anos depois, em 1986, a explosão de um reator nuclear em Chernobyl (Ucrânia) aumentou a consciência ambiental na Europa e promoveu condições favoráveis à implementação de políticas ambientais (FREY, 2000). Na década de 1980, houve também o vazamento de gases tóxicos de uma indústria de agrotóxicos em Bhopal (Índia), que resultou na aprovação da Convenção 174 da Organização Internacional do Trabalho (OIT), voltada para a prevenção dos acidentes industriais e para a redução dos seus riscos e consequências (POTT; ESTRELA, 2017).

Um fenômeno semelhante de aperfeiçoamento reativo de políticas ambientais ocorreu recentemente no estado de Minas Gerais, Brasil, após as rupturas das barragens de contenção de rejeitos de Fundão, em Mariana, no ano de 2015, e B1, em Brumadinho, no ano de 2019. Tais desastres causaram, além de centenas de vítimas humanas, danos biofísicos e socioeconômicos. A magnitude desses danos trouxe à tona uma série de falhas e limitações nas políticas voltadas para a gestão de segurança e

emergência de barragens (MILANEZ *et al.*, 2019). Diversas mudanças legais e regulatórias, nos níveis estadual e federal, foram desencadeadas pelos rompimentos dessas barragens. Entretanto, esse processo de aprendizagem político-institucional resta disperso e marginalmente explorado.

O presente artigo procurou responder às seguintes perguntas: Como o governo do estado de Minas Gerais monitora e aperfeiçoa suas políticas ambientais? Como os desastres afetaram o aprendizado institucional-regulatório do estado? Mais especificamente, o estudo teve dois objetivos principais: 1) identificar os mecanismos utilizados pelo governo Minas Gerais para aperfeiçoar políticas ambientais; e 2) entender como que os desastres de Mariana e Brumadinho afetaram as políticas de segurança e emergência de barragens.

2 APRENDIZADOS POLÍTICO-INSTITUCIONAIS PÓS-DESASTRES

Eventos indesejados podem revelar disfunções organizacionais e promover reflexões a respeito da capacidade de análise, diagnóstico e prevenção dos atores envolvidos, sendo uma oportunidade para o diálogo e aprendizagem colaborativa entre grupos e organizações (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015; LLORY; MONTMAYEUL, 2014). As catástrofes, em especial, possuem um considerável "nível de alavancagem" para desencadear mudanças, uma vez que atraem a atenção de gestores, reguladores e demais partes interessadas, gerando uma pressão significativa para investigar, compreender e implementar melhorias, inclusive no sistema regulatório (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

O processo de aprendizagem pós-desastre, entretanto, não é trivial: diversos obstáculos técnicos, organizacionais ou culturais precisam ser superados (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015). A aprendizagem envolve a identificação de deficiências e a implementação de mudanças em vários níveis do sistema, onde há diferentes atores envolvidos. Os governos, por meio do estabelecimento de leis, tornam explícitas as prioridades e definem limites, orientando ou restringindo o comportamento de órgãos públicos e empreendedores. Na sequência, as leis são interpretadas e implementadas na forma de regulamentos. Para serem operacionais, os regulamentos são adaptados no contexto dos empreendimentos, tendo em vista os recursos e procedimentos existentes. Por fim, no nível técnico-operacional, as exigências legais são colocadas em prática (RASMUSSEN, 1997). Além dessas interações, os diversos atores são influenciados durante o processo de aprendizagem por "pressões externas", sejam elas políticas, econômicas ou tecnológicas, conforme ilustra a Figura 1.

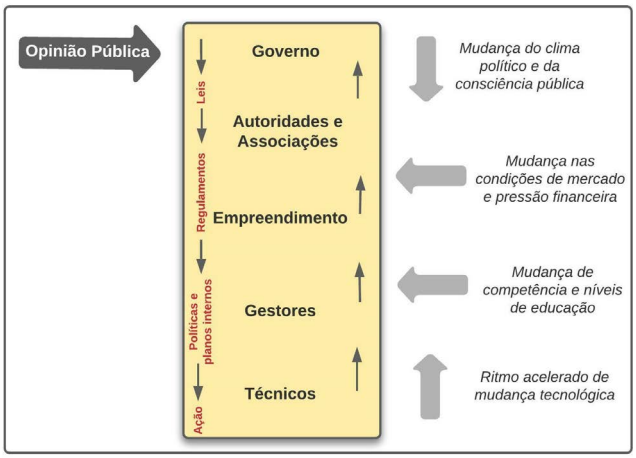

Figure 1 | Interações entre atores no processo de criação e aperfeiçoamento de políticas, leis e regulamentos

Fonte: Adaptado de RASMUSSEN (1997)

O aprendizado pós-desastre engloba as etapas de relatar, analisar, planejar, implementar e monitorar eficácia (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015). Algumas questões organizacionais ou culturais, entretanto, contribuem para deficiências no aprendizado, tais como: a ausência ou baixa qualidade de registros; a ausência de análises estatísticas e de análises de tendências para basear decisões acerca de futuros investimentos ou mudanças organizacionais; desconhecimento das causas-raízes; restrição de recursos humanos e financeiros, entre outros (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Em muitos casos, os aprendizados político-institucionais no contexto pós-desastre se traduzem em leis e regulamentos. O que, por si só, não garante a efetividade das exigências. Para Barros *et al.* (2012), os requisitos legais apenas são eficientes se forem bem aplicados, cumpridos e assimilados pelos agentes sociais. Esses autores afirmaram ainda que:

> Ter boas leis é o primeiro e mais importante passo, mas não basta. A norma é apenas um ponto de partida. Para a sua efetividade, é necessário estabelecer condições que viabilizem sua aplicação, como a contratação de técnicos especializados, infraestrutura adequada e recursos financeiros para a consecução dos trabalhos, além de um público instruído e sensibilizado com as questões ambientais (BARROS et al., 2012, p.173).

Ademais, o entendimento das causas de um desastre, por si só, não contribui para o aprendizado político-institucional. A mudança comportamental das organizações, sejam elas empreendimentos ou órgãos públicos, a busca constante por conhecimentos técnicos e o senso crítico das partes interessadas são alguns dos fatores preponderantes para a aprendizagem a partir de catástrofes. A ação, portanto, é determinante para a aprendizagem (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Cumpre, finalmente, destacar que aprendizados limitados levam à reincidência de desastres. A ruptura da Barragem de Fundão, em 2015, exemplifica essa questão. Apesar das diversas mudanças ocorridas nos instrumentos de gestão da segurança e emergência de barragens após o ocorrido, houve o segundo desastre em Brumadinho, mas ainda mais catastrófico que o primeiro em termos de perdas de vidas humanas. Essa situação sinaliza que as análises dos desastres foram superficiais, limitando-se à identificação das causas diretas, como as falhas técnicas e humanas. As causas-raízes, que são geralmente organizacionais, não foram devidamente sanadas (EUROPEAN SAFETY, RELIABILITY & DATA ASSOCIATION, 2015).

Um estudo técnico do grupo Poemas (2015), publicado logo após o desastre de Mariana, indicou limitações no aprendizado institucional por parte dos órgãos ambientais e fiscalizadores de barragens nos níveis estadual e federal. Tais instituições passavam por um processo estrutural de sucateamento, carência de pessoal, equipamentos e recursos para promoção de fiscalização mais efetiva e eficiente. Mesmo após os desastres, a Agência Nacional de Mineração (ANM) segue enfrentando restrições orçamentárias e atrasos na disponibilização de recursos, que prejudicam o desenvolvimento das ações planejadas (AGÊNCIA NACIONAL DE MINERAÇÃO, 2020). Os rompimentos dessas barragens de rejeito em Minas Gerais oferecem, portanto, um terreno fértil para se avaliar aperfeiçoamentos reativos de políticas ambientais.

3 EVOLUÇÃO DAS POLÍTICAS DE SEGURANÇA E EMERGÊNCIA DE BARRAGENS DE REJEITO NOS ÂMBITOS ESTADUAL E FEDERAL

No início do século 20, foram construídas as primeiras barragens de contenção de rejeitos oriundos de atividades minerárias. Anteriormente, os rejeitos eram descartados diretamente no meio ambiente, pois seus impactos eram considerados desprezíveis ou aceitáveis pelo poder público (ÁVILA, 2012). Barragens de contenção de rejeitos são estruturas complexas que carecem de normativas rígidas e

de gestão adequada, de forma a reduzir as incertezas a elas associadas. Além dos riscos inerentes aos métodos construtivos, as propriedades dos rejeitos mudam ao longo do tempo e comumente as alturas dos projetos são excedidas (INTERNATIONAL COMMISSION ON LARGE DAMS, 2001).

Após a década de 1960, foram estabelecidas no Brasil as primeiras diretrizes para a gestão de segurança de barragens por meio da instituição atualmente denominada Comitê Brasileiro de Barragens (CBDB). Nas décadas de 1980 e 1990, o CBDB publicou livros sobre barragens brasileiras, procedimentos de segurança e diretrizes para inspeção, auscultação e instrumentação (MELLO; PIASENTIN, 2011).

No âmbito governamental, no final da década de 1980, foi criado pelo Ministério de Minas e Energia um grupo de trabalho com o objetivo de normatizar procedimentos preventivos e de manutenção voltados para a segurança de barragens. Esse grupo elaborou relatório tratando de monitoração e instrumentação, da periodicidade de inspeção, de procedimentos gerais a serem seguidos em casos de acidentes e da definição das responsabilidades pela execução das ações (MELLO; PIASENTIN, 2011).

Em 1996, o CBDB elaborou minuta de Portaria contendo diretrizes para a avaliação da segurança das barragens e propondo a criação do Conselho Nacional de Segurança de Barragens. Porém não foi dado prosseguimento a essa proposta pelo governo. Em 1999, o CBDB elaborou o Guia Básico de Segurança de Barragens (MELLO; PIASENTIN, 2011).

Em 2002, iniciou-se em Minas Gerais o Programa de Gestão de Barragens, indicando critérios para classificação das estruturas, requisitos mínimos a serem incluídos no sistema de gestão, bem como a serem considerados nos estudos ambientais pertinentes às etapas de licenciamento das barragens (MINAS GERAIS, 2002).

O pioneirismo de Minas Gerais está em grande parte relacionado aos eventos de ruptura ocorridos anteriormente, nos anos de 1986 e 2001. Durante a década de 2000, foram estabelecidas no estado diretrizes para a realização de auditorias técnicas de segurança e a obrigatoriedade de apresentação da Declaração de Condição de Estabilidade (DCE) das barragens ao órgão ambiental.

A inserção legal do Brasil na temática de segurança de barragens se deu com a promulgação da Lei n.º 12.334/2010, que estabeleceu a Política Nacional de Segurança de Barragens (PNSB). O projeto de lei que culminou nessa lei iniciou-se após rupturas de barragem ocorridas em 2001 e 2003 em Minas Gerais, que reforçaram a necessidade de se aprovar legislação específica sobre o tema (ESTANISLAU; BELLEZZIA, 2017; MELLO; PIASENTIN, 2011). Ademais, reconheceu-se o elevado nível de problemas de natureza organizacional, com vulnerabilidades latentes em projetos, construção e operação de estruturas existentes (AGÊNCIA NACIONAL DE MINERAÇÃO, 2018).

Antes da PNSB havia iniciativas isoladas de alguns empreendedores no sentido de implantar em suas instalações brasileiras os mesmos padrões operacionais e de segurança adotados internacionalmente em suas barragens (AGÊNCIA NACIONAL DE MINERAÇÃO, 2018). No âmbito público, havia uma desarticulação entre os órgãos, que lidavam isoladamente com a problemática das barragens (ZONTA; TROCATE, 2016). Nesse sentido, a política foi uma tentativa de ampliar o controle de barragens pelo poder público, com base na fiscalização e na compilação de informações, permitindo o gerenciamento da segurança de barragens (BRASIL, 2010).

A PNSB se fundamenta no fato de que o empreendedor é o responsável legal pela segurança da barragem, cabendo-lhe o desenvolvimento de ações para garanti-la, tais como a implementação de um efetivo sistema de gestão, obedecendo às regulamentações estabelecidas pelos respectivos órgãos fiscalizadores. No caso das barragens de mineração, a fiscalização da segurança de barragens cabe à Agência Nacional de Mineração (ANM), sem prejuízo das ações fiscalizatórias dos órgãos ambientais integrantes do Sistema Nacional do Meio Ambiente (Sisnama).

À ANM cabe o estabelecimento de regulamentos para a gestão de segurança e emergência das barragens de mineração. Em 2012 e 2013 foram promulgadas normativas que, após a ruptura de Fundão, se unificaram e incorporaram aprendizados do desastre ocorrido (BRASIL, 2012, 2013, 2017).

Após o desastre de Brumadinho, foi proposto um projeto de lei que culminou na promulgação da Lei n.º 14.066/2020, que alterou a PNSB, incorporando novas exigências. Tanto em âmbito estadual quanto federal, observou-se um intenso processo de mudanças regulatórias, levando ao estabelecimento de diversas normativas (BRASIL, 2020).

Em Minas Gerais, após o rompimento da barragem de B1, estabeleceu-se a Política Estadual de Segurança de Barragens (Pesb), por meio da Lei nº. 23.291/2019, aplicável a barragens de disposição de rejeitos, resíduos, água ou líquidos que estejam associados a processos industriais ou mineração, sendo mais restritiva que a PNSB em termos de critérios de enquadramento (MINAS GERAIS, 2019).

A Pesb estabeleceu como princípios a prevalência da norma mais protetiva ao meio ambiente e às comunidades e a prioridade para as ações de prevenção, fiscalização e monitoramento, pelos órgãos e pelas entidades ambientais estaduais. Ainda, determinou que estes deverão articular-se com os órgãos e entidades responsáveis pela PNSB para compartilhamento de informações e ações de fiscalização. As exigências da Pesb foram regulamentadas em atos normativos específicos, conforme ilustra a Figura 2.

Figure 2 | Política Estadual de Segurança de Barragens e suas regulamentações

Source: Autores (2021)

3.2 AMOSTRA E INSTRUMENTO DE PESQUISA

A população da pesquisa foram empresas que compõem a cadeia agroindustrial do trigo. No total, a amostra foi composta por 91 empresas (cerca de 58% do total de questionários enviados) e pode-se dizer que a amostragem foi do tipo aleatória, pois a seleção das empresas foi feita de forma que cada membro da população tinha a mesma probabilidade de ser escolhido (MARCONI; LAKATOS, 1996). Como estratégia de entrada de campo, foi utilizado o correio eletrônico (e-mail) para envio dos instrumentos de coleta de dados, como, também, entrevistas via contato telefônico. Foram coletadas informações dos gestores de área, gestores de qualidade de produto e processo e gestores da área de sustentabilidade. A coleta dos dados ocorreu durante o período compreendido entre 09 de dezembro de 2019 e 12 de maio de 2020.

Como instrumento de coleta de dados, foi utilizado um questionário semiestruturado, contendo perguntas dicotômicas, tricotômicas, de múltipla escolha, escalar (escala Likert de 5 pontos) e numéricas, perguntas abertas e campo para observações. Esse questionário é composto por 17 perguntas, sendo

dividido em duas partes: a primeira utilizada para descrever a empresa respondente; a segunda para verificar quais as práticas voltadas para a Agenda 2030 e os ODS que a empresa praticava.

Após a elaboração e aquisição das respostas do formulário, foi desenvolvido o banco de dados no *software* estatístico *Statistical Package for the Social Sciences* (SPSS 17.0) para aferir todas as análises estatísticas. Para as análises descritivas, foram utilizadas medidas de proporção e frequências e posteriormente gráficos para melhor visualização dos resultados. Em complemento, utilizaram-se técnicas estatísticas não paramétricas, sendo que, de acordo com Siebert e Siebert (2017), a escolha de métodos não paramétricos traz a vantagem de, além de outras coisas, poder ser aplicados utilizando dados nominais e ordinais, não ficando dependentes apenas das variáveis de intervalo e razão (SIEBERT; SIEBERT, 2017).

Quanto à intenção de determinar se havia diferenças estatisticamente significativas entre três grupos de uma variável independente em uma variável dependente contínua ou ordinal, foi utilizado o teste H de Kruskal-Wallis (K-W), ou para dois grupos de uma variável independente o teste de U Mann-Whitney. Havendo diferença estatisticamente significativa entre as médias, foi realizado o teste de Bonferron (teste *post hoc*) para fazer as múltiplas comparações. Nessas análises, o porte das empresas foi considerado como variável dependente e as demais variáveis, independentes. Foi também utilizado o coeficiente de correlação de Spearman para identificar a correlação entre duas variáveis ordinais, no caso, a correlação existente entre as motivações e dificuldades encontradas pelas empresas em relação à implementação da Agenda 2030 e seus respectivos ODS.

4 METODOLOGIA

Este estudo avaliou o contexto de Minas Gerais, que é um estado de destaque na produção mineral brasileira com décadas de experiência na implementação de diversos tipos de políticas ambientais, inclusive aquelas voltadas para a gestão de segurança e emergência de barragens. Nesta pesquisa foram adotadas duas abordagens qualitativas de coleta e análise de dados: entrevistas semiestruturadas e análise de conteúdo.

Nas entrevistas semiestruturadas, o pesquisador realiza perguntas predeterminadas, mas abertas, de modo a se obter maior profundidade das respostas. Dessa forma, têm-se maior controle sobre os tópicos investigados do que em entrevistas não estruturadas e não há um intervalo fixo de respostas para cada pergunta (AYRES, 2008). Optou-se por essa abordagem metodológica para que perguntas flexíveis e abertas propiciassem o entendimento do objeto de investigação por parte dos participantes.

As entrevistas foram realizadas com oito profissionais atuantes nos órgãos do Sistema Estadual de Meio Ambiente (Sisema). Os entrevistados foram intencionalmente escolhidos, pois o objetivo não foi atingir uma amostra com representatividade estatística, e sim, uma amostra por saturação. Buscou-se entrevistados com conhecimento e experiência em diferentes instrumentos de política ambiental.

As entrevistas foram conduzidas por chamadas telefônicas, que duraram em média 45 minutos (entre 30 e 60 minutos), e foram gravadas por meio de um aplicativo, tendo sido posteriormente transcritas e analisadas. Todos os entrevistados estavam cientes do objetivo do trabalho, bem como da garantia de anonimato de suas respostas. Todos assinaram um Termo de Consentimento Livre e Esclarecido (TCLE) previamente aprovado pelo Comitê de Ética em Pesquisa (CEP) da Universidade Federal de Ouro Preto (Ufop). Os entrevistados foram codificados de modo a preservar suas identidades (P1 a P8). Na Tabela 1, está apresentado o detalhamento da metodologia utilizada nas entrevistas.

Tabela 1 | Metodologia utilizada nas entrevistas semiestruturadas

Número de respondentes	*Oito (identificados como P1 a P8)*
Datas das entrevistas	Janeiro/2019, Fevereiro/2019 e Março/2020
Perfil dos entrevistados	Gestores e analistas da Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável (Semad), Instituto Estadual de Florestas (IEF), Instituto Mineiro de Gestão das Águas (Igam) e Fundação Estadual do Meio Ambiente (Feam), responsáveis pela implementação e controle de instrumentos de política ambiental
Conteúdo das entrevistas	Perfil e experiência do respondente, controles de desempenho (administrativo e territorial), desafios e prioridades no aperfeiçoamento de instrumentos de política ambiental
Tipo de perguntas	Abertas
Tipo de questionário	Semiestruturado
Meio de comunicação	Chamadas telefônicas (gravadas por meio de aplicativo)
Análise dos dados	Transcrição e seleção dos conteúdos pertinentes

Fonte: : Autores (2021)

Por meio das entrevistas, buscou-se investigar o primeiro objetivo do estudo, qual seja, como o desempenho das políticas ambientais é acompanhado e avaliado pelo governo estadual. Mais especificamente, foram explorados os seguintes temas: quais tecnologias, ferramentas ou indicadores são utilizados; quais são os principais desafios enfrentados e qual a percepção dos profissionais sobre a efetividade das políticas ambientais no estado. Por efetividade, no contexto desta pesquisa, entende-se como sendo o alcance do objetivo proposto por uma política, seja ele a mudança ou a manutenção de determinadas condições ambientais. Vale ressaltar que o intuito das entrevistas foi obter um panorama geral e, portanto, não foram discutidas especificidades de um ou outro instrumento de política ambiental.

A análise de conteúdo das políticas, leis e regulamentos voltados para a gestão de segurança e emergência de barragens, por sua vez, demandou uma leitura atenta da matéria textual (KRIPPENDORFF, 2004). Esse método incluiu a categorização de dados textuais qualitativos em grupos de entidades semelhantes para identificar padrões consistentes e relações entre variáveis ou temas (JULIEN, 2008). O método se mostrou propício para a análise da evolução temporal dos instrumentos legais voltados às barragens de mineração.

Inicialmente, foi realizado o levantamento das leis e regulamentos publicados até 31/05/2021 no âmbito estadual, em Minas Gerais, e no âmbito federal, aplicáveis às barragens de mineração. Para a análise temporal dessa legislação, foi elaborada uma matriz, tendo como marcos as datas das rupturas das barragens de Fundão e B1 (05/11/2015 e 25/01/2019, respectivamente). Na matriz, foram elencadas as mudanças legais e infralegais ocorridas após as rupturas. Na sequência, buscou-se discutir o processo de aprendizagem desencadeado pelos referidos desastres.

5 RESULTADOS E DISCUSSÕES

5.1 AVALIAÇÃO DO DESEMPENHO E EFETIVIDADE DE POLÍTICAS AMBIENTAIS EM MINAS GERAIS

Foram apontados pelos entrevistados uma série de empecilhos que dificultam ou impedem o controle do desempenho de políticas ambientais em Minas Gerais. A falta de acompanhamento sistemático da melhoria da qualidade ambiental; a ausência de monitoramento constante dos dados ambientais; sistemas inconsistentes, que se restringem a controles administrativos e até mesmo a inexistência de sistemas foram alguns dos itens relatados.

O participante P1, que já ocupou diversos cargos de gerência de políticas de áreas protegidas e unidades de conservação, afirmou que *"Existem algumas ferramentas que a gente utiliza que trazem alguns indicadores, mas eles são pouco significativos [...] não tem esse acompanhamento sistemático em relação à qualidade ambiental do território".* O participante P2, que tem larga experiência gerencial na área de fiscalização e sanções administrativas, relatou que utiliza um sistema básico que não tem capacidade de verificar a efetividade do instrumento ante a qualidade ambiental.

Os entrevistados citaram a importância da utilização de sistemas para a gestão dos instrumentos de política ambiental e, consequentemente, o controle de seu desempenho. Porém foram relatados diversos problemas nos sistemas existentes, tais como baixa confiabilidade, necessidade de modernização e adequação ao dia a dia das atividades. O entrevistado P6, que atua na gestão de políticas de recursos hídricos e de desenvolvimento sustentável, afirmou: *"[...] hoje nosso banco de dados é muito inconsistente porque o sistema antigo não tem algumas travas que garantem a consistência dos dados lançados pelos analistas, sabe?"* Já o referido gestor de fiscalizações e sanções, P2, relatou que *"[...] o sistema tem alguma condição de gerar alguns relatórios sim, mas a gente não utiliza isso no dia a dia".* E completou: *"a gente precisa de um sistema melhor, isso não tenho dúvida [...] tem até um problema de confiabilidade nele também".*

A precária sistematização e disponibilização de dados relatada pelos participantes desta pesquisa não é uma questão recente nos órgãos ambientais em Minas Gerais. Ribeiro (2005) detectou em seu estudo que, em muitos casos, os dados existiam nas instituições, mas não estavam disponíveis de forma sistematizada, havendo a necessidade de coletá-los em vários relatórios. Essa situação também foi observada por Assis et al. (2012) em uma análise acerca da avaliação de políticas ambientais brasileiras.

A escassez de informações sobre o desempenho das políticas ambientais coordenadas pelo governo estadual dificulta a atuação dos órgãos públicos na implementação e aperfeiçoamento das políticas, bem como na priorização de esforços, levando a disparidades do ponto de vista institucional: enquanto alguns instrumentos dispõem de pessoal e recursos para sua execução, outros recebem pouca atenção e são subutilizados.

Com relação à efetividade dos instrumentos de política ambiental, houve diferentes percepções entre os entrevistados. Isso já era esperado, uma vez que diferentes instrumentos possuem características, efeitos, níveis de regulamentação e maturidade institucional distintos. Foi relatado pelo participante P4, que possui ampla experiência em exploração florestal e intervenções ambientais, que quando há um emaranhado de normas sobre determinado instrumento de política ambiental, gera-se uma grande complexidade e pouca efetividade prática.

Já os participantes P2, P3, P5 e P7 consideraram efetivas as políticas ambientais estaduais, argumentando que elas contribuem para o controle da poluição e da degradação ambiental, atuam como barreiras para a ocupação de áreas verdes ou como um componente educativo, em se tratando de aplicação

de penalidades por danos ambientais. Essa percepção de que a inexistência de políticas agravaria a qualidade ambiental corrobora a visão de Moura (2016), que afirmou:

> [...] há a percepção de que muitos problemas ambientais vêm se agravando no país, enquanto os instrumentos idealizados para a política ambiental não têm avançado – no ritmo e na intensidade suficientes – nas mudanças necessárias para melhor gestão do meio ambiente. Ainda assim, não há dúvidas de que a deterioração da qualidade ambiental neste período teria sido mais grave se estas ferramentas de naturezas regulatória, econômica, voluntária ou de informação não tivessem sido empregadas para enfrentar os problemas ambientais (MOURA, 2016, p. 139-140).

Vale ressaltar, entretanto, que "contribuir para um objetivo" e "alcançar um objetivo", como se pressupõe no conceito de efetividade, são questões distintas.

A limitação de recursos humanos, baixos investimentos em qualificação técnica das equipes, insuficiência ou má distribuição de recursos financeiros, decisões distorcidas por influências políticas, falta de articulação entre os órgãos ambientais, ausência de prioridades claras e enfoque na análise documental em detrimento da fiscalização foram apontados pelos entrevistados como os principais gargalos para a efetividade de instrumentos de política ambiental. Os participantes P1, P2 e P3 externalizaram durante as entrevistas que:

> *(não é efetivo) pela falta de recursos, e recursos incluem pessoas e recursos financeiros também. Então falta dinheiro e a gente perde muito tempo tentando resolver as coisas e no final sempre esbarra em alguma decisão de governo, falta de recursos, uma virada de ano, uma burocracia de Estado [...] (P1).*
>
> *[...] o meio ambiente tem muitos focos diferentes, tem o licenciamento, tem a fiscalização, então a gente fica numa panela, esperando muitas outras prioridades serem atendidas (P2).*
>
> *[...] o dinheiro é usado para várias outras coisas, menos para sua atividade-fim, para a sua finalidade efetiva [...] o dinheiro que é arrecadado não é aplicado como ele deveria ser (P3).*

Para Moura (2016), são fatores determinantes para a qualidade de políticas ambientais as estruturas institucionais e os processos de participação que envolvam agentes sociais e econômicos. Para o autor, o envolvimento da população na elaboração, execução e avaliação de políticas é um dos pilares para o seu sucesso. Com relação a isso, foi citado pelos entrevistados que a participação pública nas políticas ambientais ocorre por meio de consultas, reuniões, audiências, câmaras técnicas e conselhos. A gestão participativa foi citada nas entrevistas como um importante passo para a efetividade dos instrumentos, o que corrobora Assis et al. (2012, p. 18), que afirmaram: "É fundamental que sejam incorporados na avaliação os diferentes atores, que podem ter visões e objetivos conflitantes".

Apesar do reconhecimento da importância da participação da sociedade civil para a formulação de políticas públicas ambientais efetivas, há em Minas Gerais questões estruturais que levam à pseudoparticipação social nas audiências públicas e câmaras do Copam, por exemplo (CARNEIRO, 2005; MOURA, 2016; SALHEB et al., 2009).

As entrevistas realizadas demonstraram um certo despreparo e uma certa desarticulação dos órgãos ambientais estaduais na avaliação de desempenho das políticas e reforçaram a obscura relação de causa e efeito entre as políticas e a qualidade ambiental. A falta de prioridades e evidências de efetividade prejudica o aprimoramento das políticas, pois diversos aspectos relevantes, como a capacidade de gestão dos órgãos e entidades ambientais, não são considerados na tomada de decisão. As dificuldades e desafios com relação à avaliação do desempenho de políticas ambientais apontados pelos entrevistados também foram identificados na literatura.

Foi observado que em Minas Gerais há dificuldades em se medir os avanços das políticas ambientais devido à falta de mecanismos de avaliação estruturados. Para Moura (2016), sem esses mecanismos, a resposta quanto à efetividade que vem sendo alcançada mostra-se imprecisa ou parcial.

Não foi evidenciada, portanto, a existência de um sistema de aprendizado contínuo, o que prejudica a atuação preventiva desses órgãos. Assim, a ocorrência de desastres no estado é um dos sintomas da ineficiência de políticas. Os eventos indesejados tornam-se catalisadores de um processo de aprendizado que, de forma reativa, busca aperfeiçoamentos baseados nas causas e consequências do ocorrido.

As dificuldades apresentadas, todavia, não podem representar um impedimento para a avaliação de desempenho de políticas ambientais. Devem reforçar a busca por conhecimentos e investimentos para que a avaliação seja útil para direcionar os rumos das políticas, propiciando o seu aperfeiçoamento e a alocação eficiente dos recursos públicos, a partir de mecanismos participativos e democráticos.

5.2 APRENDIZADOS PÓS-DESASTRES EM MINAS GERAIS: ANÁLISE DE ALTERAÇÕES LEGISLATIVAS ACERCA DA GESTÃO DE SEGURANÇA E EMERGÊNCIA DE BARRAGENS

A segunda parte deste estudo focou mais especificamente as alterações das políticas voltadas à gestão de segurança e emergência de barragens, que refletem claramente uma reação aos desastres de Mariana e Brumadinho. O objetivo desta etapa foi entender os detalhes das alterações e o "vulto" dos aprendizados ocorridos. Tal etapa, porém, não se baseou em entrevistas, mas, como ficou explicado na seção de metodologia, em análises de conteúdo de leis e regulamentos. Identificou-se, conforme se evidencia na Tabela 2, uma intensa atividade legislativa e regulatória após o desastre de Mariana e, sobretudo, após o desastre de Brumadinho.

Tabela 2 | Leis e regulamentos voltados para a gestão de segurança e emergência de barragens para contenção de rejeitos

LEGISLAÇÃO ESTADUAL	
Pré-desastre de Mariana	
Resolução Semad nº. 99/2002	29 de janeiro de 2002
Deliberação Normativa Copam nº. 62/2002	17 de dezembro de 2002
Deliberação Normativa Copam nº. 74/2004	9 de setembro de 2004
Deliberação Normativa Copam nº. 87/2005	17 de junho de 2005
Deliberação Normativa Copam nº. 124/2008	9 de outubro de 2008
Decreto Estadual nº. 44.844/2008	25 de junho de 2008
Pós-desastre de Mariana	
Decreto n°. 46.892/2015	20 de novembro de 2015
Lei Estadual nº. 21.972/2016	21 de janeiro de 2016
Decreto Estadual n°. 46.993/2016	2 de maio de 2016
Deliberação Normativa Copam nº. 210/2016	21 de setembro de 2016
Deliberação Normativa Copam nº. 217/2017	06 de dezembro de 2017
Deliberação Normativa Copam nº. 228/2018	28 de novembro de 2018

Pós-desastre de Brumadinho	
Resolução Semad nº. 2.762/2019	29 de janeiro de 2019
Resolução Conjunta Semad/Feam nº. 2.765/2019	30 de janeiro de 2019
Lei Estadual nº. 23.291/2019	25 de fevereiro de 2019
Resolução Conjunta Semad/Feam nº. 2.784/2019	21 de março de 2019
Ofício Circular GMG/Cedec nº. 02/2019	25 de junho de 2019
Resolução Conjunta Semad/Feam nº. 2.833/2019	26 de agosto de 2019
Decreto Estadual nº. 47.739/2019	18 de outubro de 2019
Decreto Estadual nº. 48.078/2020	5 de novembro de 2020
Decreto Estadual nº. 48.140/2021	25 de fevereiro de 2021
Resolução Conjunta Semad/Feam/IEF/Igam nº. 3.049/2021	2 de março de 2021
Portaria IMA nº. 2047/2021	31 de março de 2021
Portaria Iepha/MG nº. 7/2021	9 de abril de 2021
Portaria Feam nº. 678/2021	6 de maio de 2021
Portaria Feam nº. 679/2021	6 de maio de 2021
Instrução Técnica GMG/Cedec nº. 01/2021	21 de maio de 2021
LEGISLAÇÃO FEDERAL	
Pré-desastre de Mariana	
Lei Federal nº. 12.334/2010	20 de setembro de 2010
Portaria DNPM nº. 416/2012	03 de setembro de 2012
Portaria DNPM nº. 526/2013	09 de dezembro de 2013
Pós-desastre de Mariana	
Portaria DNPM nº. 14/2016	15 de janeiro de 2016
Portaria Secretaria Nacional de Proteção e Defesa Civil nº. 187/2016	26 de outubro de 2016
Portaria DNPM nº. 70.389/2017	17 de maio de 2017
Pós-desastre de Brumadinho	
Resolução Conselho Ministerial de Supervisão de Respostas a Desastres nº. 1/2019	28 de janeiro de 2019
Resolução Conselho Ministerial de Supervisão de Respostas a Desastres nº. 2/2019	28 de janeiro de 2019
Resolução ANM n°. 4/2019	15 de fevereiro de 2019
Resolução ANM n°. 13/2019	8 de agosto de 2019
Resolução ANM n° 32/2020	11 de maio de 2020
Resolução ANM n° 40/2020	6 de julho de 2020
Lei Federal nº. 14.066/2020	30 de setembro de 2020
Resolução ANM nº. 51/2020	24 de dezembro de 2020
Resolução ANM nº. 56/2021	28 de janeiro de 2021

Fonte: Autores (2021)

O estudo identificou que houve, particularmente em Minas Gerais, um processo incremental de aprendizado. Anos antes da publicação da PNSB já havia no estado um sistema de classificação de barragens e já eram exigidos documentos e dados sobre as estruturas durante o processo de licenciamento ambiental. O estado foi percursor de diversas mudanças, que posteriormente foram implementadas em nível federal para barragens de mineração, bem como para outras tipologias de barragens. A Tabela 3 exemplifica esse pioneirismo.

Tabela 3 | Exemplos de requisitos estabelecidos de forma pioneira em Minas Gerais

Descrição	*Âmbito estadual*	*Âmbito federal (barragens de mineração e/ou outras tipologias)*
Cadastro de Barragens	Res. Semad nº. 99/2002	Lei Federal nº. 12.334/2010
Determinação do credenciamento de profissionais que atestam estabilidade de barragens	Lei Estadual nº. 23.291/2019	Lei Federal nº. 14.066/2020
Determinação da definição de medidas para resgatar pessoas, animais e patrimônio cultural, mitigar impactos ambientais e assegurar o abastecimento de água	Lei Estadual nº. 23.291/2019	Lei Federal nº. 14.066/2020
Determines upstream dam 'de-characterization' (decommissioning)	Resolution Semad/Feam n° 2.765/2019	Resolution ANM nº. 4/2019
Determinação da análise e aprovação do PAE	Decreto Estadual nº. 48.078/2020	Resolução ANM nº. 51/2020
Estabelecimento de diretrizes para elaboração do estudo de inundação	Ofício GMG/Cedec nº. 02/2019	Resolução ANM nº. 32/2020
Determinação de reuniões públicas para apresentação do PAE	Lei Estadual nº. 23.291/2019	Lei Federal nº. 14.066/2020

Fonte: Autores (2021)

Observa-se que alguns aprendizados catalisados pela ruptura da barragem de Fundão foram concretizados apenas após a ruptura da barragem B1. Um exemplo é a implementação da Política Estadual de Segurança de Barragens, fruto do Projeto de Lei de Iniciativa Popular denominado "Mar de Lama Nunca Mais", proposto em julho de 2016. Após rompimento da barragem B1, percebeu-se a urgência e relevância da referida lei, tendo sido sancionada um mês após o ocorrido.

Foi necessária, portanto, a ocorrência de dois desastres para a concretização de algumas determinações no âmbito estadual, tais como: detalhamento da metodologia dos estudos de inundação; licenciamento ambiental obrigatoriamente trifásico para barragens; exigência de caução para garantir a recuperação socioambiental; audiências públicas para discussão do projeto conceitual da barragem; licença de operação condicionada à aprovação do PAE (por parte de diversos órgãos setoriais); exigência da priorização das alternativas de disposição que minimizem os riscos socioambientais e promovam o desaguamento dos rejeitos e resíduos; criação do Sistema de Informações de Gerenciamento de Barragens (Sigibar) e compatibilização do sistema de classificação de barragens estadual ao federal.

No âmbito federal, a ANM, principalmente após a ruptura da barragem B1, estabeleceu novas exigências relativas à gestão de segurança e emergência de barragens. Ademais, foi firmado um acordo de cooperação com a Organização para a Cooperação e Desenvolvimento Econômico (OCDE)

para revisão da regulação e governança do setor mineral. O intuito da ANM é identificar as barreiras regulatórias que dificultam a implementação de políticas públicas e corrigir as ineficiências no setor mineral, com base nas melhores práticas mundiais de países como Canadá, Austrália e Estados Unidos (AGÊNCIA NACIONAL DE MINERAÇÃO, 2020). Em seu relatório preliminar, a OCDE destacou a necessidade de otimização das atividades fiscalizatórias, com o intuito de reduzir os riscos de acidentes (AGÊNCIA NACIONAL DE MINERAÇÃO, 2021).

Grande parte do esforço das instituições públicas e privadas tem se concentrado no aperfeiçoamento da gestão da emergência, por tratar de procedimentos que podem evitar rompimentos ou minimizar os danos decorrentes deles, principalmente em se tratando de perdas de vidas.

Vale citar que, em resposta ao desastre de Brumadinho, estabeleceu-se o Padrão Global da Indústria sobre Gerenciamento de Rejeitos que objetivou, a partir das lições aprendidas com as recentes rupturas e das boas práticas existentes, estabelecer diretrizes em prol da gestão segura de barragens de rejeito (UNITED NATIONS ENVIRONMENT PROGRAMME; INTERNATIONAL COUNCIL ON MINING AND METALS; PRINCIPLES FOR RESPONSIBLE INVESTMENT, 2020). Apesar de terem prevalecido os interesses da indústria minerária em sua elaboração, o Padrão definiu princípios e requisitos auditáveis que enfatizam a relevância do engajamento e comunicação junto às partes interessadas ao longo de todo o ciclo de vida das barragens (HOPKINS; KEMP, 2021).

A análise realizada constatou que alterações nas determinações legais, entretanto, não são claramente suficientes para evitar novos desastres. É necessário que empreendedores, de fato, cumpram as exigências estabelecidas e que os órgãos fiscalizadores e reguladores tenham recursos financeiros e humanos suficientes para monitorar o cumprimento de suas determinações. Caso as leis e regulamentos desconsiderem a capacidade dos órgãos fiscalizadores ou das entidades licenciadoras, a efetividade das determinações será comprometida. As mudanças regulatórias, portanto, devem ser acompanhadas do fortalecimento dos órgãos de controle.

6 CONSIDERAÇÕES FINAIS

A avaliação de políticas ambientais possibilita a compreensão de suas implicações e o seu aperfeiçoamento, sendo também base para a legitimação de decisões políticas, auxiliando os governos a tomarem decisões mais científicas e baseadas em evidências, contribuindo para uma melhor distribuição e utilização de recursos (ASSIS et al., 2012; BELLONI; SOUZA; MAGALHÃES, 2003; CRABBÉ; LEROY, 2008; MICKWITZ, 2006).

No Brasil, entretanto, efeitos socioambientais das políticas nem sempre são monitorados, impossibilitando sua avaliação e, consequentemente, a aprendizagem político-institucional e a atuação preventiva. Especificamente em Minas Gerais, identificaram-se relatos que sugerem haver um certo despreparo e uma certa desarticulação dos órgãos ambientais estaduais na avaliação de políticas. Nesse cenário, os desastres ambientais tornam-se importantes percursores do aperfeiçoamento de políticas, como ficou claro no caso dos aperfeiçoamentos legislativos e regulatórios voltados para a gestão de barragens de mineração.

As rupturas das barragens de Fundão e B1 impulsionaram diversas discussões sobre a efetividade das políticas de segurança e emergência de barragens, e seguramente aceleraram o processo de aperfeiçoamento de tais políticas. Muito embora se lamente a falta de lições técnicas aprendidas com o desastre de Fundão, de forma a se evitar o segundo incidente, ocorrido em Brumadinho (MILANEZ, 2021).

Neste artigo, foram elencados diversos desafios institucionais enfrentados em Minas Gerais que dificultam ou impedem o controle das políticas ambientais e, consequentemente, a definição de

prioridades quanto ao seu aperfeiçoamento. No presente estudo, foram obtidas evidências empíricas acerca da capacidade das instituições públicas e constatou-se que a percepção dos profissionais atuantes nos órgãos ambientais estaduais corrobora a visão de autores que exploraram este tema.

Em se tratando da gestão de segurança e emergência de barragens, a avaliação realizada revelou que as mudanças ocorridas não foram meras coincidências: a maioria, senão todas, possui relação direta com as causas ou consequências de ambos os desastres. Os avanços da segurança de barragens poderiam ocorrer em decorrência dos estudos, metodologias e boas práticas disseminadas entre os profissionais, mas não na velocidade e intensidade observadas.

Os desafios enfrentados para a efetividade dessas políticas relacionam-se, principalmente, ao descompasso entre a existência de leis e sua implementação prática; aos cortes orçamentários, de pessoal e de recursos técnicos; e ao desconhecimento ou descaso com relação aos benefícios das políticas, nos diferentes níveis de gestão. Nesse sentido, considera-se que para a efetividade das determinações legais é necessário, entre outros aspectos, o fortalecimento da capacidade institucional dos órgãos de controle.

Os desastres ocorridos demonstraram que o "risco zero", em se tratando de barragens, não existe, por melhores que sejam os projetos de engenharia e os requisitos legais que acautelam essas estruturas. É necessário que empreendedores, de fato, cumpram as exigências estabelecidas e que os órgãos fiscalizadores e reguladores tenham recursos humanos e financeiros suficientes para monitorar o cumprimento de suas determinações.

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São Paulo's strategic master plan and the challenges of sustainable urban transformation

Plano Diretor estratégico de São Paulo e os desafios para a transformação urbana sustentável

Adalberto Gregório Back [1]

Gabriela Marques Di Giulio [2]

Tadeu Fabrício Malheiros [3]

[1] PhD in Political Sciences, Researcher, Environmental Health Department, Faculty of Public Health, Universidade de São Paulo (USP), São Paulo, Brazil
E-mail: backgregor@gmail.com

[2] PhD in Environment and Society, Associate Professor, Environmental Health Department, Faculty of Public Health, Universidade de São Paulo (USP), São Paulo, Brazil
E-mail: ggiulio@usp.br

[3] PhD in Public Health, Associate Professor, Hydraulics and Sanitation's Department, Engineering School of São Carlos, Universidade de São Paulo (USP), São Carlos, Brazil
E-mail: tmalheiros@usp.br

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ABSTRACT

Cities play an essential role in the challenge of sustainability, and urban planning is one of the main tools for guiding urban transformation processes. This paper analyses the São Paulo Master Plan 2014, considering the principles and guidelines on compact cities, sustainable adaptation and ecosystem-based adaptation. An urban development model within sustainable parameters, however, involves conflict dynamics. In this sense, the views and demands of the main stakeholders seeking to influence the regulatory arena of São Paulo's urban policy are mapped. The analysis focuses on attempts to change the zoning law that would affect several of the definitions agreed in the Master Plan, prioritising mainly the interests of real estate developers.

Palavras-chave: Adaptation. Compact city. Urban planning. Sustainable urban transformation.

RESUMO

As cidades têm um papel importante no desafio da construção de um modelo de desenvolvimento em parâmetros sustentáveis, sendo o planejamento urbano um dos principais instrumentos para orientar processos de transformação urbana. O presente artigo realiza uma análise sistemática do Plano Diretor de São Paulo 2014 à luz dos princípios e diretrizes sobre cidade compacta, adaptação

sustentável e adaptação baseada em ecossistemas. Tais instrumentos regulatórios, no entanto, não são isentos de dinâmicas de conflitos. Nesse sentido, mapeiam-se as visões e demandas dos principais atores que buscam exercer influência na arena regulatória da política urbana paulistana analisando-se duas tentativas de alteração extemporânea da Lei de Zoneamento que afetariam várias das definições pactuadas no Plano Diretor, priorizando sobretudo os interesses de incorporadoras imobiliárias.

Keywords: *Adaptação. Cidade compacta. Planejamento urbano. Transformação urbana sustentável..*

1 INTRODUCTION

Cities play a central role in the challenge of an inclusive, safe, resilient, low-carbon and sustainable development model as postulated in international UN agreements, such as the 2030 Agenda for Sustainable Development, New Urban Agenda (Habitat III), Paris Agreement on Climate Change and the Sendai Agreement on Resilient Cities and Disaster Risk Reduction (KLUG, 2018; ROMERO-LANKAO et al., 2018; SOTTO et al., 2019).

The challenge for sustainability transitions in cities involves a multiplicity of themes (LOORBACH *et al.*, 2017). In this sense, it is important to differentiate what we mean by sustainable urban development and sustainable urban transformation. In McCormick's definition (2013), sustainable urban development would be sustainable development from a broader perspective that occurs in urban areas' social, economic, environmental and physical dimensions. Sustainable urban transformation, on the other hand, emphasises the development of the urban regions involving changes that occur from *governance* and *planning* related to the production and management of urban space, especially transformations in urban design with the potential to generate dynamics of inclusive development, low carbon emissions, safe and resilient. Sustainable urban change, in this sense, is more restricted than the notion of sustainable urban development and involves interventions on the territory (ERNST *et al.*, 2016; MCCORMICK *et al.*, 2013; WAMSLER *et al.*, 2014).

Part of the literature has pointed to guidelines for sustainable urban transformation involving notions such as a compact city (BIANCO *et al.*, 2011; EICHHORST, 2009; EVERS *et al.*, 2018; GEHL, 2013; JACOBS, 2011), sustainable adaptation (CHU *et al.*, 2017; MIRANDOLA *et al.*, 2015; RIBEIRO; SANTOS, 2016; WALNUT; KENNEL, 2017) and ecosystem-based adaptation (BRINK *et al.*, 2016; GENELETTI; ZARDO, 2016; LAFORTEZZA *et al.*, 2013; WAMSLER *et al.*, 2014). This paper analyses the São Paulo Master Plan 2014 (SPMP), considering the main elements that constitute these concepts, particularly the urban morphology and design regulations in city planning (SÃO PAULO, 2014).

However, it is essential to emphasise that sustainable urban transformation implies a normative character, an ideal development model. In this sense, that is an inherently political process involving conflict and agreement dynamics between different stakeholders with different views and interests on urban development (ROMERO-LANKAO *et al.*, 2018; WAMSLER *et al.*, 2013).

The São Paulo Master Plan 2014 (SPMP) brings innovations that aim to change historical paradigms of urbanisation in the city, especially in urban mobility, social housing and environmental sustainability, being a pioneer in the implementation of several urbanistic instruments present in the Statute of Cities[1] (BONDUKI; ROSSETTO, 2018; FRANCO *et al.*, 2015; LEITE *et al.*, 2015).

One of the most outstanding achievements of the SPMP was the adoption of a set of self-applicable regulatory instruments contributing to the effectiveness in implementing some of its main guidelines. This characteristic is an advance in the Brazilian context. After all, historically, the master plans are marked by being essentially rhetorical and with low effectiveness in implementation, to the

extent that they rarely present self-applicable regulations and precise definition of the necessary resources, limiting themselves to a programmatic agenda (ULTRAMARI *et al.*, 2015; VILLAÇA, 2005).

The urban instruments and guidelines of municipal master plans can be classified into two dimensions: 1) regulatory arena: rules on occupation and densification of urban areas that limit and restrict the real estate production activity, but also to guide and promote incentives for certain forms of land-use and occupation; 2) redistributive arena: guidelines for State intervention in urban space, functioning as a political agenda for implementation in the medium and long term, but which depends on political will and commitment, as well as the allocation of budgetary resources in the future (LOWI, 1972; VILLAÇA, 2005).

The dynamics of conflicts, interests and agreements between stakeholders occur in different ways in those arenas. On the one hand, in the regulatory arena of urban policy, the stakeholders seek to influence the legal-normative framework that configures urban development policy (Master Plan; Zoning Law; Building Code). On the other hand, in the redistributive arena, the stakeholders seek to influence the distribution of investments in the city, involving the management of urban policy.

The regulatory arena was under pressure for extemporaneous changes in the zoning law between late 2017 and early 2018 (SMUL, 2017) and, later, in the last quarter of 2019 (SMUL, 2019), with proposals that would alter the essence of several devices agreed in the master plan. In the redistributive arena, in turn, several dimensions related to the programmatic guidelines of São Paulo's urban policy defined in the SPMP did not advance as predicted (SÃO PAULO, 2019b).

The São Paulo Master Plan should be in force until 2029 but will be revised in 2021/2022. In this context, it becomes relevant to reflect on the advances and challenges for urban development in São Paulo, given the objectives of sustainable urban transformation. This paper thus seeks to:

1º) Identify policies and regulatory instruments provided for in the 2014 SPMP converging with normative guidelines of safe, resilient, low carbon and environmentally sustainable urban development model, according to assumptions found in the theoretical literature.

2º) Map the views, interests and demands of the main stakeholders. They seek to influence the regulatory arena of urban policy to identify convergences or distancing from their needs with the objectives of sustainable urban transformation, as defined herein.

2 METHODOLOGY

First, from a non-systematized review of the literature on urban governance of climate change, this research provides a synthesis of the main elements that constitute the concepts of a) compact city, b) sustainable adaptation, and c) ecosystem-based adaptation, particularly involving elements related by local governments on land-use and occupation.

In this sense, from a qualitative analysis of São Paulo's Master Plan (SÃO PAULO, 2014), it was possible to identify urban instruments and policies capable of operationalising and implementing the guidelines related to these principles, considering particularly the dimension of urban and environmental policies related to morphology and urban design in the municipality. These instruments and policies were analysed and discussed based on the urban governance literature on climate change, urbanism, and urban policy in the Brazilian and São Paulo contexts.

In addition, this paper identifies and classifies urban policy instruments into two categories: i) regulatory arena: regulations that impose limitations on the individual, without the need for a subsequent regulation for its effectiveness, and ii) programmatic guidelines: attributions to the

public authorities themselves that require new rules for their effective implementation and, therefore, require political will and subsequent allocation of budgetary resources.

In the regulatory arena, we mapped the main stakeholders that sought to influence the untimely process of revising the zoning law, notably: a) real estate developers, b) middle-class neighbourhood associations present in the expanded centre of the city, and c) social housing movements. To this end, we collected and analysed the drafts of the proposed revision, as well as the drafts of the meetings that debated such proposals in two moments: i) the first attempt took place between December 2017 and February 2018, less than two years after the last revision of the zoning law (SMUL, 2017), and ii) the second attempt took place between October and December 2019 (SMUL, 2019). Regarding the first proposal to amend the law and read the drafts, we analysed the meetings recorded and made available on YouTube. Concerning the second zoning revision proposal, we conduct participant observations in their open meetings, open letters and requests for judicial suspension of the process of amending the zoning law, as well as journalistic material aimed at identifying their positions in the regulatory arena of urban policy. Finally, we collect data produced by private stakeholders such as open letters, requests for judicial suspension of the zoning law revision, and journalistic material focused on identifying their positions in the regulatory arena of urban policy.

Regarding the implementation of the programmatic guidelines, secondary sources were taken as subsidies, such as public authority transparency data available on electronic websites2, in addition to updated academic articles.

3 COMPACT CITY

Strategies for achieving a compact urban growth model can be guided by land-use planning through transit-oriented development methodologies that propose territorial principles to be followed: i) compact urban growth with measures that encourage constructive and population density close to the transport axes (CARLTON, 2009); ii) Intensive and mixed use of urban land that brings housing, work, services and leisure closer together, forming interconnected centralities through public transport infrastructure, in order to shorten the distances between home and work and reduce the distances to travel and the dependence on individual motorized transport (JACOBS, 2011), contributing to the reduction of travel by private motor vehicles, and thus reduce local air pollution and GHG emissions (KENNEDY *et al.*, 2009); iii) recapture of the added value generated by real estate valuation in order to promote the redistribution of the benefits obtained, especially by fostering housing of social interest (HSI) in regions with consolidated urban infrastructure and the supply of formal jobs (EVERS et al., 2018); iv) disincentive to individual motorized transport, whether charging fees or limiting garages on public transport axes (EICHHORST, 2009).

In addition to densification and multiple land-uses, the orientation of urban development in a compact way must consider the social inclusion of low-income population with a housing of social interest in areas with a consolidated urban infrastructure. After all, in Brazilian cities, the dynamics that induce urban expansion are related mainly to the housing deficit and the lack of low-income housing options in areas closer to the centre (JENKIS; BURGESS, 2004).

The planning of inclusive, safe and quality transport must take into account a traffic system based on the diversification and connection of transport modes, including non-motorized modes (active mobility as walking or cycling) in addition to the expansion of the high-capacity public transport network, capable of generating higher levels of accessibility and allowing for a reduction in the intensity of travel by individual motorised transport (GEHL, 2013). Furthermore, the diversification and interconnection of modes reduces emissions of pollutants and local GHGs and allows alternative

routes to respond to extreme weather events, such as heavy rains and floods, which are increasingly frequent and intense, observed in cities (EICHHORST, 2009).

Finally, urban planning aiming at a compact city (Box 1) should consider the urban design that induces greater energy efficiency of buildings. After all, structural aspects of the city related to the built environment can positively or negatively affect the urban energy demand related to the need for heating and cooling of buildings because of the structure, orientation and conditions of buildings and streets in the circulation of winds, insolation and shading, consequently impacting the levels of GHG emissions in a city (BIANCO *et al.*, 2011).

Box 1 | Principles on Compact City

- To restrict urban sprawl;
- To plan compact cities and reduce daily commuting;
- To discourage the use of individual motorised transport;
- To increase the constructive and population density in consolidated urban areas;
- To prioritise the development of the city along with public transport axes;
- To promote the use of different modes of transport, prioritising non-motorized transport (active mobility) and public transport of medium and high capacity;
- To build smaller blocks with more sidewalk coverage, more pedestrian crossings, smaller street width, smaller indentations of buildings, more street trees and shading of roads;
- To promote mixed uses of urban land including residential, commercial, leisure and cultural services close to each other, keeping the streets active at different times of the day;
- To promote social mixing in regions with consolidated infrastructure and with the provision of formal jobs shortening the distances between home and work;
- To use materials and urban design standards aimed at the energy efficiency of buildings.

Source: Authors' elaboration.

A set of self-applicable regulatory instruments is present in the SPMP that guide urban development, following the guidelines for designing compact cities. The basis for these innovations is the definition of the coefficient of the essential construction potential equal to the size of the land (CB1) in force throughout the city (BONDUKI; ROSSETTO, 2018; LEITE *et al.*, 2015).

Buildings higher than CB1 require Charges for Additional Building Rights (OODC, acronym in Portuguese) in exchange for more intensive urban land use, only possible with public investments. The application of the OODC provided a substantial increase in extra-budgetary resources for investments in the city, which were previously fully appropriated by real estate producers. Such resources are destined to the Municipal Urban Development Fund (Fundurb), of which at least 30% should be allocated to the implementation of public transport, cycle and pedestrian traffic systems[3], as well as another 30%, should be given for the acquisition of land for housing of social interest (HSI), prioritising consolidated urban areas[4] according to the guidelines defined by the SPMP (FRANCO *et al.*, 2015).

Up to 2014, Fundurb's resources were freely distributed among the secretariats according to political discretion. The master plan, in turn, created sub-bindings of Fundurb's resources to ensure an urban development agenda that prioritised policies for social housing and infrastructure to public transport and active mobility[5] (PAIM, 2019).

Around the medium and high-capacity public transport axes, called structuring axes of urban transformation, the SPMP defined a set of incentives to promote constructive and population densification, allowing maximum constructive coefficients of 4 times the lot size (CM4). That can be added by 20% if the active façade (trade and services) is taken on the ground floor of the building

to link it to the public space and induce the mixed uses of urban land. In addition, progressive discounts are offered in the financial compensation to build above the primary index, the higher the rate of constructive use of buildings in these areas (BONDUKI; ROSSETO, 2018).

To ensure population density, the instrument called maximum quota-part defines that the housing units in the buildings present in the public transport axes have an average of 80m2 built area. This leads to diversification in the size of housing units, also contributing to stimulating urban occupations that meet different income ranges.

The SPMP also defined restrictions on the number of garages considered in the urban structuring axes. Thus, up to one garage per residential unit for every 70 m² of built area in non-residential developments is allowed. Above these limits, garages can be computed as built-up areas and charged for additional building rights in projects located along the structural axes. In this sense, the disincentive to the motorised private car is promoted, mass public transport is encouraged, and the valuable construction space in the urban structuring axes is expanded (LEITE *et al.*, 2015).

Encouraging building density on public transport routes is only possible if, on the other hand, there are restrictions on density throughout the city. In this sense, the master plan determined limitations to density and fertilisation outside the axes of mass public transport. Particularly the mixed and centrality zones have a construction limit of twice the size of the land, building height limits of 28m in diverse areas and 48m in central areas, restricting real estate production in the core of the upper-middle-class neighbourhoods (SÃO PAULO, 2014).

Finally, it is necessary to highlight the urban consortium operations (OUC) that aim to encourage and guide the density in urban voids on the railway edge and land of old abandoned factories in central regions with infrastructure. The OUCs need approval in a specific law and may have densification rules higher than the maximum density allowed in the municipality. In urban operations, certificates of additional constructive potential (Cepacs) are bid for raising funds in advance for reinvestment in public works and interventions for the transformation and valuation of real estate in this previously delimited area, with 25% of the funds collected must be invested in social housing in the surrounding region.

The instrument of urban operations is controversial. On the one hand, it is under the principles of a compact city to promote constructive densification in empty urban areas with infrastructure. However, on the other hand, it concentrates public investments in restricted areas that are already valued in the municipality, to the detriment of investments in the city as a whole, favouring the interests of contractors, real estate developers, private builders and property owners in these regions, whose properties are overvalued in expropriation processes (NOBRE, 2019).

Table 1 systematises the urban instruments of the master plan that aim to operationalise the guidelines and principles related to a compact city model.

Table 1 | Compact City and the SPMP 2014

Principles	*Guidelines*	*Instruments*		*Applicability*
Urban development guided by the axes of mass transport	Constructive Density	CB1 throughout the city	CM 4 OODC Discounts	Self-applicable on axes
	Population density	Maximum part dimension	Limit to average apartment size	Self-applicable on axes
	Mixed uses of urban soil	Active façade	Trade and services on the ground floor of buildings	Self-applicable on axes
	Expansion of the structuring axes	Fundurb: 30% for public transport infrastructure and active mobility		Political orientation
	Block qualification	Minor blocks Restrictions on walls Larger sidewalks Smaller buildings retreats		Self-applicable on axes
Disincentive to the use of individual motorised transport	Garage limits	Garage limits as non-computable areas in the total of the built area		Self-applicable on axes
Urban development in underutilised areas with infrastructure	Constructive density on the railway and former industrial areas	Consortium urban operations with delimited areas in the SPMP		Specific legislation
		Urban intervention projects		

Source: Authors' elaboration.

Most instruments related to the compact city model were defined as self-applicable regulatory instruments. This characteristic gives more excellent stability to the implementation of these guidelines. However, several of these regulations were pressured in the regulatory arena with attempts to change the zoning law in late 2017 and early 2018 and again in November 2019. Notably, in 2017, the principal instruments under pressure from real estate developers and that affect the principles of the compact city are i) discounts on the charges for additional building rights; (ii) greater flexibility in the rules for garages in buildings on public transport routes; iii) extinction of the height limits for buildings in the core of the neighbourhoods (SMUL, 2017).

The demand for discounts on the financial compensation paid for the right to build implies a reduction in Fundurb resources, distributed in investments throughout the city, mainly in social housing and urban mobility. In this sense, the demand of real estate developers goes against the objectives of reducing socio-territorial inequalities, directly affecting the interests of social movements for housing (SMUL, 2018b).

The extinction of height limits in the core of neighbourhoods, in turn, leads to a verticalisation of buildings and, potentially, to a dispersed constructive density in the city, which contradicts the principles of a compact city. In addition, such demand by real estate developers goes against the interests of upper-middle-class neighbourhood associations located in the so-called expanded centre of the city, which have as one of their main demands the maintenance of low-density horizontal neighbourhoods, justified in terms of protecting locality features (SMUL, 2018b). The central region's demand for low construction and population density with consolidated urban infrastructure and high formal jobs also contradicts the compact city principle.

Regarding investments in the city, in 2019, two changes were observed in the criteria defined in the Master Plan for the minimum allocation of Fundurb resources. Firstly, the use of the resource for the

construction of housing units by the government was allowed, in addition to the restricted use of mere land acquisition, as initially defined. Then, it was possible to use resources in the road system in a broad sense. In the first case, the legislative change corrected a distortion, given that the focus is on ensuring the greater supply of HSI. However, in the second, the change distorts the purpose of investments in active mobility and bus lanes, considering that the resources for these areas start to compete with the road infrastructure works.

The master plan provided for the implementation of 208 km of bus corridors by 2016, in addition to the current 160 km preexisting. By 2025 it was expected to implement another 322 km totalling 690km in all. However, only 11.8 km was implemented up to date, with the most significant delays in lower-income areas in the east and north of the city (TOMASIELLO *et al.*, 2021). Given that the areas with the highest population density occur in the city's periphery, the difficulty in expanding efficient public transport to these regions highlights the enormous challenge of guiding urban transformation towards a compact city model (SOMEKH; MILITELLI, 2021).

4 SUSTAINABLE ADAPTATION

The notion of sustainable adaptation assumes that development must promote both local adaptations to the effects of climate change in the urban context, with measures that contribute to social equity and environmental integrity, two pillars of sustainable development (BROWN, 2011). Adaptation to the effects of climate change is understood as adjustment processes to anticipate impacts and reduce vulnerabilities related to climate variability at the local/regional level (IPCC, 2007).

In this sense, interventions for sustainable adaptation should simultaneously address actions in the short and long term to promote climate risk management and reduce poverty and vulnerabilities (EAKIN *et al.*, 2014).

Thus, risk management is associated with a specific approach to adaptive capacity that considers aspects related to the ability to anticipate, identify and respond to a given risk (AGRAWAL; LEMOS, 2015). On the other hand, the generic adaptive capacity approach is convergent with promoting sustainable development in a perspective that reduces social inequalities and promotes environmental sustainability (BROWN, 2011; DI GIULIO *et al.*, 2016).

Our analysis focuses on the housing policy and risk management policy agreed in the Master Plan, considering the capacity to intervene in urban morphology that promotes the reduction of socio-territorial inequalities in the municipality and the reduction of vulnerabilities and interventions in risk areas (Box 2).

According to the National Civil Defence Policy (2012), the adoption of measures to reduce the risk of disasters is shared among federal entities in the Brazilian context. Still, it is up to the municipalities to identify the risk areas. Thus, municipalities are responsible for the elaboration of geotechnical charters of aptitude for urbanisation that guides the fragilities and potentialities of the territory from its physical characteristics, the processes that generate risk situations and the existing forms of land use and occupation that must be considered in the zoning law to ensure the safety of new land parcels (NOGUEIRA; KENNEL, 2017).

The elaboration of a Municipal Risk Reduction Plan (MRRP) would be a tool capable of managing risks in the city in a systemic and integrated manner. Its objective is to map areas of geological and hydrological risks, define costs of the necessary actions and possible sources of resources to subsidise environmental recovery programs, land regularisation measures, structural activities and eventual reallocations of populations in risk areas (MIRANDOLA *et al.*, 2015).

Land regularisation and the housing supply of social interest focused on the lower-income groups of the population in urbanised areas are converging measures to reduce socio-territorial inequalities and contain urban sprawl. However, the feasibility of housing projects faces financial barriers to its effective implementation, and it is essential to consider the existence of institutional mechanisms that guarantee regular resources focused on housing (RIBEIRO; SANTOS, 2016).

Box 2 | Principles for increasing adaptive capacity and urban resilience

- To restrict urban sprawl;
- To develop geotechnical charters of aptitude for urbanisation;
- To avoid the installation of urban infrastructure in hazardous areas;
- To restrict urban development in areas prone to floods and landslides;
- To promote the offer of housing of social interest and land regularisation;
- To develop buildings for resettlement of populations in risk areas;
- To develop Municipal Risk Reduction Plans that contain mappings of risk areas with the budgeting of the resources needed for structural containment measures;
- To improve drainage systems;
- To perform regular maintenance of infrastructure.

Source: Authors' elaboration.

The 2014 Master Plan regulates a set of instruments to promote the reduction of socio-territorial urban inequalities while reducing vulnerabilities and improving socio-environmental risk management. In this sense, it stands out: i) the provision of regular resources for housings of social interest; ii) the reservation of land in consolidated urban areas to provide housing for the low-income population; iii) urban instruments to curb the idleness of urban real estate and give social function to the property; iv) the urbanisation of slums, land regularisation of precarious urban settlements and resettlement of people living in risk areas and environmental preservation areas.

The funds raised from the charges for additional building rights are destined to the Municipal Urban Development Fund (Fundurb), of which 30% must be allocated to housing of social interest (HSI) and provide regular extrabudgetary resources for investment in the municipality, aiming at the redistribution of urban capital gains (FRANCO et al., 2015). In the urban consortium operations, in turn, 25% of the amounts collected should be allocated to HSI in precarious settlements around them. In the latter case, however, the amounts collected remain concentrated in a specific region of the city (NOBRE, 2019).

The solidarity quota, in turn, is an urban instrument that determines that large real estate projects (above 20,000 m2) must produce HSI or donate resources equivalent to 10% of the area of their enterprise to HSI (ALBUQUERQUE et al., 2015).

In addition to the provision of regular resources for housing, the 2014 master plan expanded the delimitation of special areas of social interest (ZEIS, *acronym in Portuguese*), involving: i) land regularisation and urbanisation of slums (ZEIS 1); ii) housing supply in urban voids (ZEIS 2); iii) production and renovation of housing on underutilised land or properties in areas with consolidated urban infrastructure, services and formal jobs, generally located in the central region of the city (ZEIS 3); iv) production of HSI in watershed protection areas, which are endowed with previous urban infrastructure, aimed exclusively at the population transferred from risk areas and the margins of dams (ZEIS 4); and v) housing supply to a middle class in urban voids close to the central region of the city (ZEIS 5).

In all ZEIS, the constructive densification allowed is equivalent to 4 times the lot size. In ZEIS 1, 2, 3 and 4, the government and private developers must offer as a rule at least 60% of the housing units of the building for income range up to 3 minimum wages (HSI 1). The remaining housing units can be offered according to the following parameters: 20% more for HSI 1 (up to 3 minimum wages) or HSI 2 (3 to 6 minimum wages) and the remaining 20% for the popular housing market (PHM), aimed at the public with an income of 6 to 10 minimum wages. This was an important advance in the 2014 SPMP related to the demand for social movements for housing and aims to meet the higher demand for housing concentrated in the lower-income layers.

However, the areas classified as ZEIS 5 apply different rules for the supply of housing units per income range, meeting the demand of real estate sectors that operate in this segment and that pressed for a higher percentage of destination for the public with income between 6 to 10 minimum wages. In ZEIS 5, therefore, 40% can be allocated to HSI 1 or HSI 2, and up to 60% can be allocated to PHM (BONDUKI, 2018).

Concerning the instruments that aim to give social function to the property and curb the idleness of urban real estate, since 2010, São Paulo has legislation that regulates the instrument of Parcelling and Building Compulsory (PEUC, *acronym in Portuguese*) and its derivatives: Progressive urban property tax over time (IPTU, *acronym in Portuguese*) and Expropriation with payment insecurities. However, its application was flawed, not generating legal obligations to notify owners. The 2014 master plan established precise rules. It expanded the areas that could be used for implementing the PEUC in qualified areas of the city, including ZEIS 2, 3 and 5, in consortium urban operations areas, Sé and Mooca subprefectures, areas of influence of the axes of structuring urban transformation, urbanised areas, as well as glebes larger than 20,000m2 in peripheral areas of the city (BONDUKI; ROSSETTO, 2018).

Concerning the measures that contribute to risk reduction and management, it is worth highlighting the geotechnical charter of aptitude for urbanisation and the municipal risk reduction plan. The geotechnical charter prevents formal constructions in areas prone to geological risk at the time of the construction permit. Despite being an important planning and information tool, the geotechnical charter does not regulate the formal occupations, which are most dwellings in risk areas in the municipality.

The Municipal Risk Reduction Plan was foreseen in the Master Plan as an instrument that should be elaborated identifying vulnerable areas and populations to geological and hydrological risks, budget estimates on the resources needed with structural actions (such as slope containment, for example) and/or relocation of populations at risk to reduce vulnerabilities and address the risks in the city in an integrated and systemic way. However, seven years after the publication of the SPMP, little progress has been made in developing this vital planning and risk management tool in the city.

Table 2 systematises the main instruments present in the SPMP converging with the guidelines of an urban development model to reduce socio-territorial inequalities and vulnerabilities.

Table 2 | Sustainable adaptation

Principles	*Guidelines*	*Instruments*	*Applicability*
Social function of the city	Regular resources for social housing	CB1 in the whole city Payment of financial compensations to build above the CB1 Solidarity Quota Urban development fund (Fundurb)	Self-applicable regulation
	Land reserve for HSI in qualified areas	Delimitation of ZEIS in the SPMP	
Social function of property	Urbanisation of slums	Increased density allowed	
		ZEIS 3 HSI 1 = 60% ZEIS 1, 2, 4 HSI 2 = 40%	Self-applicable regulation
		ZEIS 5 HSI 1 and HSI 2 = 50%	
Reduction of socio-spatial inequalities	Land regulation	Municipal Housing Plan	Specific law
	Expand the supply of urban equipment in vulnerable areas	Fundurb: 30% para HSI	Allocation by political decision
		Parceling and Building Compulsory (PEUC) Progressive IPTU	Optional by the public authori-ties
		Urban and social equipment network plan	Allocation by political decision
	Prevent buildings in hazardous areas	Geotechnical charter	Self-applying instrument
Reducing the risk of landslides	Containment bar-riers Resettlement of populations in risk areas	ZEIS 4 Fundurb Resources	Allocation by political decision
		Municipal Risk Reduction Plan (MRRP)	Inter-secretarial municipal plan

Source: Authors' elaboration.

As mentioned earlier, the regulatory arena of urban policy was the subject of pressure from real estate developers in late 2017, less than two years after the last revision of the zoning law. Among their main demands that would influence the principles of sustainable adaptation involving the reduction of socio-territorial inequalities, the following stand out: i) reduction in the amounts of financial compensation paid for the right to build; ii) elimination of the solidarity quota that obliges sizeable real estate developments to produce or donate resources housing of social interest, in percentage terms to their project; iii) reduction of the mandatory percentage of supply of housing units for low income, from the current minimum of 60% for a pairing (50% and 50%) of the proportion of the supply of HSI 1 and other modalities aimed at higher income groups (SMUL, 2017).

These demands to change regulatory instruments meet the interests of increased profitability by real estate developers. However, they would have the consequence of reducing the resources distributed throughout the city, especially for social housing. Moreover, if such demands were implemented, it would reduce HSI supply to the lower-income groups, directly contradicting the demands of social movements for housing.

The strong opposition undertaken by both associations of upper-middle-class neighbourhoods and social movements for housing has succeeded in suspending the process of extemporaneous revision of

the zoning law. That opposition was expressed from mobilisations in public consultation meetings, the preparation of an open letter to the mayor and the subscription of a judicial petition to suspend the process of reviewing the legislation that ran counter to their interests, alleging non-compliance with the formal rites for the processing of the law (SMUL, 2018a).

In November 2019, in a new attempt to revise the zoning law, there was a retreat concerning the discount on the charge for additional building rights (OODC) and solidarity quota. In addition, the government proposed to mediate solutions to these conflicting demands. It indicated that solidarity quota could be voluntary for undertakings smaller than 500 m2 with the counterpart of gains in productive potential; ii) and maintained the initial ratio of 60% HSI 1 and 40% other modalities, however allowing a higher rate of constructive use in ZEIS without OODC since 20% of the HSI (additional) were aimed at the ranges up to 3 minimum wages (SMUL, 2019).

5 ECOSYSTEM-BASED ADAPTATION

The guidelines for ecosystem-based adaptation are related to initiatives in green infrastructure, distributed in the municipality, which generate environmental, social, economic co-benefits and the promotion of well-being and health while providing improvement in urban drainage, reduction of geological vulnerabilities to climate extreme events and reduction of heat islands in the urban fabric. In addition, such initiatives contribute to promoting the control of urban sprawl, protecting water-producing springs and ecosystems with green belts in the outskirts of the city, as well as promoting urban and peri-urban agriculture (BRINK *et al*., 2016; GENELETTI; ZARDO, 2016; LAFORTEZZA *et al*., 2013; WAMSLER *et al*., 2014).

The adaptation challenges of Brazilian cities can be faced with lower financial costs and more significant environmental gains. This is reachable by implementing green infrastructure solutions that allow the structuring of alternative drainage systems, combining low-impact solutions such as urban green corridors, hillside reforestation and green streets rather than conventional engineering measures (grey infrastructure) (HERZOG; ROSA, 2010).

Urban parks distributed in several neighbourhoods throughout the city, linear parks on the banks of streams, afforestation of streets and avenues and incentives to promote green spaces in private real estate developments are measures that contribute to: i) reducing soil waterproofing and the potential for flooding, ii) promoting microclimatic cooling and reduce the heat island effect, iii) reducing noise pollution and iv) qualify the urban landscape, performing multiple functions: ecological, aesthetic, educational, sociability and leisure (JACOBI *et al*., 2015; LAFORTEZZA *et al*., 2013).

In turn, the conservation and restoration of green belts in the peripheral areas of the city with urban forests and the incentive to urban and peri-urban agricultural production are initiatives that simultaneously contribute to protecting and preserving watershed areas, contain urban sprawl and promote livelihoods for local communities, tourism opportunities and food security (BRINK *et al*., 2016; CHU *et al*., 2017).

Box 3 | Principles on ecosystem-based adaptation

- To control the urban sprawl;
- To protect water-producing springs;
- To resize drainage systems;
- To deploy flooded squares and expand permeable areas;
- To expand urban afforestation;
- To promote the implementation of urban parks distributed throughout the city;
- To encourage the deployment of green roofs and urban gardens;
- To encourage urban and peri-urban agriculture;
- To create urban forests and green infrastructure;
- To protect ecosystems by creating green belts.

Source: Authors' elaboration.

The 2014 Master Plan recognises special treatment for the management, conservation and restoration of green areas in the text of the law. Among the main points of the environmental sustainability agenda and the containment of urban sprawl in the master plan, it is worth highlighting the delimitation of rural areas in the municipality, incentives for organic agriculture, ecotourism and payment for environmental services (FRANCO *et al*., 2015).

With these measures, the master plan aims to simultaneously promote sustainable agriculture in the city's green belt through expanding the offer of agroecological products, generating and maintaining jobs in the rural area, avoiding population evasion in the region; hindering the advancement of irregular occupations by maintaining the rural character in the region; and preserving the springs contributing to the quality of the surrounding springs, especially in the south of São Paulo. Thus, it is moving towards qualifying the use-value in environmental protection areas to contain urban expansion, not simply restricting urban use but mainly encouraging sustainable use in these areas (NAKAMURA; MARK, 2021).

In the urban space, among some main proposals of environmental qualification, we highlight the delimitation made in the master plan of areas for parks creation distributed by the municipality, the forecast for the creation of a specific fund for the implementation and management of parks, as well as the plan of afforestation of the city.

The master plan demarcated 167 areas (public and private) for the implementation of parks (urban and natural) in addition to the 121 existing parks at the time. The demarcation of these areas as special environmental protection zones (ZEPAM, *acronym in Portuguese*) restricts the constructive use by making formal real estate projects in these areas unfeasible. On the other hand, their owners can receive resources from the payment mechanism for environmental services or transfer them to the municipality, receiving monetary values in exchange (BONDUKI, 2014).

The so-called environmental quota is another relevant mechanism that accompanies the set of urban and environmental law innovations in the city. It is an urban regulatory instrument that establishes rules for an environmental qualification within the scope of the lot for new buildings from 500 m2 of the area in some areas of the municipality, as defined by the zoning law of the municipality (LPUOS, *acronym in Portuguese*) (SÃO PAULO, 2016).

The main objective of the environmental quota is to promote the creation of green spaces in construction projects in some areas of the city, aiming at increasing soil permeability and increasing vegetation cover within the lot to reduce the effects of heat island and provide better drainage of rainwater, contributing to minimise effects of flooding in the city (CAETANO, 2016; MALERONKA, 2015).

Table 3 highlights the main instruments, policies and guidelines present in the SPMP associated with the urban development model based on the principles of ecosystem-based adaptation.

Table 3 | Ecosystem-based adaptation

Principles	*Guidelines*	*Instruments*	*Applicability*
Urban sprawl control	Encourage urban and peri-urban agriculture	Delimitation of rural area in zoning	Self-applicable regulation
		Sustainable rural development plan	Programmatic Guideline
Creation of green belts on the outskirts of the city Protection of water-producing springs	Delimiting areas providing environmental services	Payment of environmental services (bids)	Programmatic Guideline
	Preserving urban forests	Municipal Plan for conservation and recovery of the Atlantic Forest	Programmatic Guideline
Flood risk reduction	Expand flooded areas and permeable areas	Environmental quota	Self-applicable regulation (LPUOS)
		Delimitation of areas for the creation of parks distributed throughout the city	Limitations in the master plan
		Resources for creating parks	Fundurb and Specific Fund
Reduction of heat islands	Urban afforestation	Urban Afforestation Municipal Plan	Programmatic Guideline

Source: Authors' elaboration.

The recognition of São Paulo's rural areas in the master plan has generated possibilities for farmers to access rural credit and markets for agroecological products, besides being a measure to contain urban expansion and maintain green areas (NAKAMURA; MARCOS, 2021). Likewise, the Payment for Environmental Services instrument proposed by the master plan contributes to the preservation and environmental recovery of ecosystems, particularly the protection of water sources (SEPE; PEREIRA, 2015).

However, the municipal environmental policy defined by the Master Plan is composed mainly of programmatic guidelines and, therefore, its practical implementation is dependent on political will and allocation of resources, especially the resources of the municipal secretary of green and environment, which are in dispute with other secretariats (DI GIULIO, 2020). In this context, the environmental policy provided for in the Master Plan was the one that has made minor progress since the enactment of the

SPMP, with the low implementation of new parks (SÃO PAULO, 2019b) and the observation of urban expansion at the expense of illegal deforestation in peri-urban forests (NATALINI, 2020).

Concerning the regulatory arena, the environmental quota was subject to an attempt to change in 2018, changing the scope of the instrument from 500 m2 to 1,000 m2 (SMUL, 2017). This proposal is based on a demand of real estate producers aiming to reduce costs and expand the constructive use. However, it would result in a decrease in the number of new buildings with incentives to adopt sustainable construction procedures, which would result in a reduction in the adaptative capacity and an increase in heat islands. In other words, the private interest in maximising profit by real estate producers would negatively affect the public interest. In 2019, there were setbacks in this proposal, but it allowed greater flexibility of the instrument involving other forms of environmental qualification (SMUL, 2019).

6 CONCLUDING REMARKS

The paper aimed to map regulatory instruments of urban policy capable of operationalising the objectives of an urban transformation towards a compact city model, which aims to reduce socio-territorial inequalities, increase resilience and environmental qualification. In this context, it was observed that the sociopolitical pact defined by the São Paulo Master Plan brought some innovations converging with these principles and guidelines.

One of the significant advances of the master plan is the self-applicable regulatory instruments in the axes of medium and high-capacity public transport for guidance aimed at the principles of a compact city. In addition, there was an increase in extrabudgetary resources for investments in the city, particularly in social housing and urban mobility.

However, in the two administrations that followed the SPMP approval, the regulatory arena was subjected to pressure from real estate producers who sought to relax regulations that would negatively affect the objectives of a compact city, related to environmental qualification and reduction socio-territorial inequities.

Among the main demands of real estate developers in the regulatory arena that would affect the objectives of a compact city, the following stand out: i) discounts on financial compensations paid for the right to build above the primary index; (ii) elimination of limits to the verticalisation of buildings in the inner core of neighbourhoods; iii) flexibilisation of computable garages as a built-up area in new buildings along public transport routes.

Regarding the demands of real estate developers that would negatively affect the objectives of reducing socio-territorial inequities and improving urban resilience, the following stand out: i) discounts on the charge for additional building rights, which would reduce resources for investments in a comprehensive manner in the city, including resources for social housing and population relocation in risk areas; ii) reduction in the mandatory percentage of supply of low-income housing units in ZEIS.

Finally, concerning the regulatory instruments of urban policy associated with an environmental qualification in new buildings, real estate developers pressed for their application to cease being mandatory for buildings smaller than 1,000 m^2, making the instrument's objectives unfeasible.

However, such proposals to change the zoning law were blocked by a coalition involving middle-class neighbourhood associations and social housing movements that saw setbacks in the sociopolitical pact established in the Master Plan and would affect their interests and views on urban development differently.

It is also worth mentioning that the Executive Power in 2019 was the guarantor of two amendments to the Master Plan on how Fundurb resources are used: i) it allowed the resources to be also used to offer social housing, in addition to the mere acquisition of land, as initially planned, correcting a distortion; ii) and it enabled the resources for urban mobility to be used unrestrictedly in infrastructure, distorting the initial purpose of complete application in infrastructure for public transport and active mobility that would need to be prioritised, especially in peripheral regions, following the objectives of interconnected cities with low carbon emissions and more energy-efficient transport.

The environmental and disaster risk reduction agendas, both more directly related to the objectives of a safe, resilient and sustainable city model, were the ones that advanced made minor progress during this period. Although there are several forecasts in the Master Plan on these agendas, most of the law's provisions are fundamentally programmatic guidelines and, in that condition, are susceptible to political commitment and allocation of resources in the future time.

In summary, the socio-political pact defined by the 2014 master plan is not stable, and during the two administrations following its approval, some pressures concurred to mischaracterise its objectives, prioritising, above all, the interests of real estate developers.

Despite the peculiarities of São Paulo's city, such as its diversified and prosperous real estate market, historically organised and active social housing movements and an upper-middle-class elite established in the expanded centre with demands for low population and construction densities, the research results presented here can serve as a reference to inspire studies on the challenges for sustainable transformation in other urban contexts.

NOTES

1 | Federal Law 10, 257 of July 10, 2001, establishes general urban policy guidelines and provides other measures.

2 | Available in: https://www.prefeitura.sp.gov.br/cidade/secretarias/licenciamento/desenvolvimento_urbano/dados_estatisticos/ Accessed on: 16 October 2020.

3 | Item II of Art. 340 of the São Paulo Master Plan (SÃO PAULO, 2014).

4 | Item I of Art. 340 of the São Paulo Master Plan (SÃO PAULO, 2014).

5 | These rules of application of Fundurb resources have undergone major changes given by law 17,217 of October 23, 2019, as will be discussed later.

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Plano Diretor estratégico de São Paulo e os desafios para a transformação urbana sustentável

São Paulo's strategic master plan and the challenges of sustainable urban transformation

Adalberto Gregório Back [1]

Gabriela Marques Di Giulio [2]

Tadeu Fabrício Malheiros [3]

[1] Doutor em Ciência Política, Pesquisador, Departamento de Saúde Ambiental, Faculdade de Saúde Pública, Universidade de São Paulo (USP), São Paulo, SP, Brasil
E-mail: backgregor@gmail.com

[2] Doutora em Ambiente e Sociedade, Professora Associada do Departamento de Saúde Ambiental, Faculdade de Saúde Pública, Universidade de São Paulo (USP), São Paulo, SP, Brasil
E-mail: ggiulio@usp.br

[3] Doutor em Saúde Pública, Professor Associado na Escola de Engenharia de São Carlos, Universidade de São Paulo (USP), São Carlos, SP, Brasil
E-mail: tmalheiros@usp.br

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ARTICLE – VARIA

RESUMO

As cidades têm um papel importante no desafio da construção de um modelo de desenvolvimento em parâmetros sustentáveis, sendo o planejamento urbano um dos principais instrumentos para orientar processos de transformação urbana. O presente artigo realiza uma análise sistemática do Plano Diretor de São Paulo 2014 à luz dos princípios e diretrizes sobre cidade compacta, adaptação sustentável e adaptação baseada em ecossistemas. Tais instrumentos regulatórios, no entanto, não são isentos de dinâmicas de conflitos. Nesse sentido, mapeiam-se as visões e demandas dos principais atores que buscam exercer influência na arena regulatória da política urbana paulistana analisando-se duas tentativas de alteração extemporânea da Lei de Zoneamento que afetariam várias das definições pactuadas no Plano Diretor, priorizando sobretudo os interesses de incorporadoras imobiliárias.

Palavras-chave: Adaptação. Cidade compacta. Planejamento urbano. Transformação urbana sustentável.

ABSTRACT

Cities play an essential role in the challenge of sustainability, and urban planning is one of the main tools for guiding urban transformation processes. This paper analyses the São Paulo Master Plan 2014, considering the principles and guidelines on compact cities, sustainable adaptation and ecosystem-based adaptation. An urban development model within sustainable parameters, however, involves conflict dynamics. In this sense, the views and demands of the main stakeholders seeking to influence the regulatory arena of São Paulo's urban policy are mapped. The analysis focuses on attempts to change the zoning law that would affect several of the definitions agreed in the Master Plan, prioritising mainly the interests of real estate developers.

Keywords: Adaptation. Compact city. Urban planning. Sustainable urban transformation.

1 INTRODUÇÃO

As cidades têm papel central no desafio do alcance do desenvolvimento inclusivo, seguro, resiliente, sustentável e de baixo carbono, como postulado em acordos internacionais no âmbito da ONU, como Agenda 2030 para o desenvolvimento sustentável, Nova Agenda Urbana (Habitat III), Acordo de Paris sobre mudanças climáticas e Acordo de Sendai sobre cidades resilientes e redução de risco de desastres (KLUG, 2018; ROMERO-LANKAO *et al*., 2018; SOTTO *et al*., 2019).

Dada a multiplicidade de temas que envolve os desafios de transições para a sustentabilidade no contexto das cidades (LOORBACH *et al.*, 2017), é importante diferenciar o que entendemos por desenvolvimento urbano sustentável e por transformação urbana sustentável. Na definição dada por McCormick (2013), desenvolvimento urbano sustentável seria o desenvolvimento sustentável sob uma perspectiva mais abrangente que ocorre nas dimensões social, econômica, ambiental e física em áreas urbanas. Já a transformação urbana sustentável dá ênfase ao desenvolvimento de áreas urbanas envolvendo mudanças que ocorrem a partir de *governança e planejamento* relacionados à produção e gestão do espaço urbano, sobretudo transformações no desenho urbano com o potencial de gerar dinâmicas de desenvolvimento inclusivo, de baixa emissão de carbono, seguro e resiliente. A transformação urbana sustentável, nesse sentido, é mais restrita que a noção de desenvolvimento urbano sustentável e envolve intervenções ancoradas no território (ERNST *et al.*, 2016; MCCORMICK *et al*., 2013; WAMSLER *et al.*, 2014).

Parte da literatura sobre governança urbana das mudanças climáticas tem apontado diretrizes para a transformação urbana sustentável envolvendo noções como cidade compacta (BIANCO *et al.*, 2011; EICHHORST, 2009; EVERS *et al*., 2018; GEHL, 2013; JACOBS, 2011), adaptação sustentável (CHU *et al*., 2017; MIRANDOLA *et al*., 2015; NOGUEIRA; CANIL, 2017; RIBEIRO; SANTOS, 2016) e adaptação baseada em ecossistemas (BRINK *et al*., 2016; GENELETTI; ZARDO, 2016; LAFORTEZZA *et al*., 2013; WAMSLER *et al*., 2014). Neste trabalho, mapeamos os principais elementos que formam esses conceitos, levando em consideração particularmente intervenções e regulamentações relacionadas ao desenho e morfologia urbana no planejamento e gestão das cidades, tomando como base o Plano Diretor Estratégico de São Paulo de 2014 (SÃO PAULO, 2014).

É importante ressaltar, no entanto, que a própria noção de transformação urbana sustentável implica um caráter normativo (*dever ser*) relacionado, portanto, a um modelo ideal de desenvolvimento. Nesse sentido, é um processo inerentemente político que envolve dinâmicas de conflito e pactuação entre diferentes *stakeholders* com visões e interesses distintos sobre o desenvolvimento urbano (ROMERO-LANKAO *et al*., 2018; WAMSLER *et al*., 2013).

O Plano Diretor de São Paulo de 2014 traz em seu bojo diretrizes e regulamentações que visam alterar paradigmas históricos da urbanização do município, especialmente no que diz respeito à mobilidade urbana, habitação social e sustentabilidade ambiental, sendo pioneiro em implementar vários dos

instrumentos urbanísticos regulatórios presentes no Estatuto das Cidades[1] de maneira autoaplicável (BONDUKI; ROSSETTO, 2018; FRANCO *et al*., 2015; LEITE *et al*., 2015).

Uma das maiores conquistas do Plano Diretor foi a adoção de um conjunto de instrumentos urbanísticos regulatórios autoaplicáveis contribuindo para a efetividade na implementação de algumas das suas principais diretrizes. Essa característica se constitui como um avanço no contexto brasileiro. Afinal, historicamente no Brasil, os Planos Diretores são marcados por serem essencialmente retóricos e com baixa efetividade na implementação, na medida em que raramente apresentam regulamentações autoaplicáveis e definição clara dos recursos necessários, limitando-se a uma agenda programática (ULTRAMARI *et al.*, 2015; VILLAÇA, 2005).

Os dispositivos, instrumentos urbanísticos e diretrizes dos Planos Diretores municipais podem ser classificados em duas dimensões: 1) arena regulatória: onde instrumentos regulatórios relacionados à delimitação de zonas urbanas e suas regras de ocupação e adensamento de maneira autoaplicável agem no sentido de limitar e restringir a atividade da produção imobiliária, mas também no sentido de orientar e promover incentivos a determinadas formas de uso e ocupação do solo; 2) arena redistributiva: onde observam-se diretrizes e propostas políticas destinadas ao próprio poder público, voltadas para a organização da intervenção estatal no espaço urbano, funcionando como uma agenda política para implementação em médio e longo prazo, mas que depende para a sua efetiva implementação da vontade e comprometimento político, bem como da alocação de recursos financeiros e orçamentários no tempo futuro (LOWI, 1972; VILLAÇA, 2005).

A dinâmica dos conflitos, interesses e pactuações entre atores ocorre de maneiras diferentes na arena política regulatória e na arena política redistributiva. Na arena regulatória da política urbana, as visões, interesses e demandas dos grupos se exercem em relação a instrumentos que definem regras no arcabouço jurídico-normativo e que formam a política de desenvolvimento urbano (Plano Diretor, Lei de Zoneamento e Código de Obras). Na arena redistributiva, por sua vez, a dinâmica de conflitos e pactuações entre os atores ocorre na distribuição e alocação de recursos orçamentários e extraorçamentários para investimentos na cidade, envolvendo a gestão da política urbana.

A arena regulatória foi alvo de pressões para alterações extemporâneas na Lei de Zoneamento entre o final de 2017 e início de 2018 (gestão Doria) (SMUL, 2017) e, posteriormente, no último trimestre de 2019 (gestão Covas) (SMUL, 2019), com propostas que alterariam a essência de vários dispositivos pactuados no Plano Diretor[2]. De outro lado, na arena redistributiva, várias dimensões relacionadas às diretrizes programáticas da política urbana paulistana definidas no PDE não avançaram como previsto (SÃO PAULO, 2019b).

O Plano Diretor deve vigorar até 2029, porém, passa por uma revisão em 2021/2022. Nesse contexto, torna-se relevante uma reflexão sobre os avanços e os desafios do desenvolvimento urbano paulistano para se alinhar aos objetivos da transformação urbana sustentável. Este artigo, assim, busca:

1º) Identificar políticas e instrumentos regulatórios previstos no PDE 2014 convergentes com diretrizes normativas de um modelo de desenvolvimento urbano seguro, resiliente, de baixo carbono e ambientalmente sustentável, conforme pressupostos encontrados na literatura teórica;

2º) Mapear as visões, interesses e demandas dos principais atores que buscam exercer influência na arena regulatória da política de desenvolvimento urbano a fim de identificar as convergências ou distanciamentos de suas demandas com os objetivos da transformação urbana sustentável, conforme aqui definido.

2 METODOLOGIA

O trabalho realizado partiu de uma abordagem dedutiva trazendo pressupostos teóricos e categorias analíticas provenientes de uma revisão bibliográfica não sistematizada da literatura de governança urbana das mudanças climáticas, envolvendo particularmente intervenções dos governos locais sobre o uso e ocupação dos solos.

Nesse sentido, a partir de uma análise qualitativa do Plano Diretor Estratégico de São Paulo (SÃO PAULO, 2014), foi possível identificar instrumentos urbanísticos e políticas previstas no PDE capazes de operacionalizar e implementar as diretrizes relacionadas aos princípios a) da cidade compacta; b) adaptação sustentável; e c) adaptação baseada em ecossistemas no município, levando-se em consideração, particularmente, a dimensão de políticas urbanas e ambientais relacionadas ao desenho e morfologia urbana no município. Os referidos instrumentos e políticas urbanas e ambientais foram analisados e discutidos a partir das literaturas de governança urbana das mudanças climáticas, urbanismo e política urbana, no contexto brasileiro e paulistano.

Tendo em vista a importância de se observar o grau de efetividade na implementação dessas políticas e instrumentos previstos no PDE, buscou-se identificar e classificar os instrumentos relacionados à arena regulatória (regulamentações que impõem limitações ao particular, sem a necessidade de um regulamento posterior para sua efetividade), bem como as políticas e diretrizes programáticas, com atribuições destinadas ao próprio poder público (dispositivos de eficácia limitada que requerem novos regramentos para sua efetiva implementação, e necessitam, portanto, de vontade política e alocação de recursos posteriores).

Na arena regulatória, foram identificados as demandas e interesses dos principais atores que buscaram exercer influência no processo de revisão extemporânea da Lei de Zoneamento: incorporadoras imobiliárias, associações de bairro de classe média presentes no centro expandido da cidade e movimentos sociais de moradia. Para tanto, foram empreendidas coleta e análise das minutas de proposta de revisão da referida lei, bem como das atas das reuniões que debateram tais propostas no âmbito do Poder Executivo em dois momentos: i) durante a gestão Doria, entre dezembro de 2017 e fevereiro de 2018 (SMUL, 2017), e ii) durante a gestão Covas, entre outubro e dezembro de 2019 (SMUL, 2019). Além da leitura das atas, também foi objeto de análise as próprias reuniões gravadas e disponibilizadas no *youtube* (relativas à primeira proposta de alteração da lei), bem como realizou-se observação participante das reuniões abertas ocorridas no processo de discussão da segunda proposta de revisão da Lei de Zoneamento, ocorridas no último trimestre de 2019. Por fim, foram coletados dados produzidos por tais atores privados durante os referidos períodos citados, tais como cartas abertas e pedidos de suspensão judicial do processo de alteração da Lei de Zoneamento, bem como material jornalístico com foco na identificação de seus posicionamentos na arena regulatória da política urbana.

Em relação à implementação das diretrizes programáticas, foram tomados como subsídios dados de fontes secundárias sobre a implementação do Plano Diretor produzidos e divulgados pela própria prefeitura, de transparência do poder público, como Geosampa e ObservaSampa, disponibilizada em meio eletrônico[3], além de artigos acadêmicos atualizados.

3 CIDADE COMPACTA

As estratégias para alcançar um modelo de crescimento urbano compacto podem ser direcionadas pelo planejamento do uso do solo por meio de metodologias de desenvolvimento orientado para o trânsito (*transit-oriented development*) que propõem princípios territoriais a serem seguidos: i) crescimento urbano compacto com medidas que incentivem os adensamentos construtivo e populacional próximos aos eixos de transportes coletivos (CARLTON, 2009); ii) construção de centralidades envolvendo uso intensivo e misto do solo urbano que aproximem moradia, trabalho, serviços e lazer e que sejam conectadas por meio de

infraestruturas de transporte público coletivo, encurtando as distâncias entre casa e trabalho, ao reduzirem as distâncias a serem percorridas e a dependência de transportes motorizados individuais (JACOBS, 2011), contribuindo para a redução dos deslocamentos por veículos particulares automotores, da poluição do ar local e das emissões de GEE (KENNEDY *et al.,* 2009); iii) recaptura da mais-valia gerada pela valorização imobiliária obtida por meio de investimentos públicos, de modo a promover a redistribuição dos benefícios obtidos, sobretudo com fomento à habitação de interesse social em regiões dotadas de infraestrutura urbana consolidada e oferta de empregos formais (EVERS *et al*., 2018); iv) desincentivo ao uso de transportes motorizados individuais, seja por meio de cobrança de taxas ou limitação de vagas de estacionamento nos eixos de transporte público (EICHHORST, 2009).

A orientação do desenvolvimento urbano de maneira compacta deve levar em consideração, além do adensamento e dos múltiplos usos do solo, também a inclusão social para a população de baixa renda com moradias de interesse social em áreas dotadas de infraestrutura urbana consolidada. Afinal, nas cidades brasileiras as dinâmicas que induzem ao espraiamento urbano estão relacionadas, em grande medida, ao déficit habitacional e à falta de opções de moradia para baixa renda em áreas mais próximas do centro (JENKIS; BURGESS, 2004).

Um planejamento para um transporte inclusivo, seguro e de qualidade deve levar em consideração, de um lado, um sistema de tráfego baseado na diversificação e conexões de modais de transporte, incluindo modais não motorizados (mobilidade ativa, como locomoção a pé ou por bicicleta) somados à ampliação da rede de transportes públicos de média e alta capacidade, capazes de gerar maiores níveis de acessibilidade e de permitir a redução da intensidade de viagens por transporte motorizado individual (GEHL, 2013). Além de reduzirem as emissões de poluentes locais e GEE, a diversificação e interconexão de modais permitem a criação de rotas alternativas para responder a eventos climáticos extremos, como chuvas fortes e enchentes, cada vez mais frequentes e intensos observados nas cidades (EICHHORST, 2009).

Por fim, o planejamento urbano visando uma cidade compacta (Quadro 1) deve levar em consideração o desenho urbano que induza maior eficiência energética de edifícios. Afinal, aspectos estruturais da cidade relativos ao ambiente construído, também regulados pelo planejamento urbano, podem afetar positiva ou negativamente a demanda urbana de energia relacionada à necessidade de aquecimento e resfriamento de edifícios, tendo em vista a estrutura, orientação e condições dos edifícios e ruas na circulação de ventos, insolação e sombreamento, impactando, consequentemente, os níveis de emissões de GEE em uma cidade (BIANCO *et al*., 2011).

Quadro 1 | Princípios sobre Cidade Compacta

- Restringir o espraiamento urbano;
- Planejar cidades compactas e reduzir os deslocamentos diários;
- Desincentivar o uso de transportes motorizados individuais;
- Aumentar a densidade construtiva e populacional em áreas urbanas consolidadas;
- Priorizar o desenvolvimento da cidade junto a eixos de transporte coletivo;
- Fomentar o uso de diferentes modais de transporte priorizando os transportes não motorizados (mobilidade ativa) e o transporte público de média e alta capacidade;
- Construir quadras menores com maior cobertura de calçada, mais passagens de pedestres, menor largura de rua, recuos menores de edifícios, mais árvores de ruas e sombreamento das vias;
- Fomentar os usos mistos do solo urbano incluindo usos residencial, comercial, serviços, lazer e cultura próximos uns dos outros, mantendo as ruas ativas em diferentes momentos do dia;
- Fomentar a mistura social em regiões dotadas de infraestrutura consolidada e com oferta de empregos formais encurtando as distâncias entre casa e trabalho;
- Utilizar materiais e padrões de desenho urbano voltados à eficiência energética de edifícios.

Fonte: Elaboração própria.

Há um conjunto de instrumentos regulatórios autoaplicáveis presente no PDE que atua no sentido de orientar o desenvolvimento urbano seguindo as diretrizes de desenho de cidade compacta. A base para essas inovações está na definição do coeficiente de aproveitamento do potencial construtivo básico igual ao tamanho do terreno (CA base1), vigente em toda a cidade (BONDUKI; ROSSETTO, 2018; LEITE *et al*., 2015).

Construções superiores ao CA base1 requerem o pagamento da Outorga Onerosa do Direito de Construir (OODC) no licenciamento da obra como contrapartida pelo uso mais intensivo do solo urbano, apenas possível em decorrência de investimentos públicos. A aplicação da Outorga Onerosa proporcionou aumento substancial nos recursos extraorçamentários para investimentos na cidade, revertendo para a sociedade os valores auferidos com a valorização imobiliária obtida pela transformação do uso do solo e que eram anteriormente apropriados pelas produtoras imobiliárias. Tais recursos são destinados ao Fundo Municipal de Desenvolvimento Urbano (Fundurb) dos quais ao menos 30% deveriam ser destinados à implantação dos sistemas de transporte público coletivo, cicloviário e de circulação de pedestres[4], bem como outros 30% deveriam ser alocados para a aquisição de terrenos voltados para habitação de interesse social, priorizando áreas de urbanização consolidada de acordo com as diretrizes definidas pelo PDE[5] (FRANCO *et al*., 2015).

Até 2014, os recursos do Fundurb eram distribuídos livremente entre secretarias de acordo com a discricionariedade política. Por proposta do governo à época, o Plano Diretor criou subvinculações dos recursos arrecadados como forma de garantir uma agenda de desenvolvimento urbano que priorizasse políticas para habitação social e para infraestrutura de transporte público e de mobilidade ativa[6] (PAIM, 2019).

No entorno dos eixos de transporte público de média e alta capacidade, denominados eixos de estruturação da transformação urbana, como corredores de ônibus e estações de metrô, o PDE definiu um conjunto de incentivos a fim de promover o adensamento construtivo e populacional permitindo coeficientes de aproveitamento máximos até quatro vezes o tamanho do lote (CA máx. 4), podendo ser acrescidos de 20% caso se adote a fachada ativa (comércio e serviços) no térreo da construção de modo a vinculá-la ao espaço público e induzir os usos mistos do solo urbano. Além disso, são ofertados descontos progressivos na Outorga Onerosa quanto maior o índice de aproveitamento construtivo das edificações nessas áreas (BONDUKI; ROSSETO, 2018).

Para garantir o adensamento populacional, o instrumento denominado cota-parte máxima define que as unidades habitacionais nos edifícios presentes nos eixos de estruturação tenham uma média de 80 m^2 de área computável como área construída. Isso induz a diversificação no tamanho das unidades habitacionais contribuindo também para estimular ocupações urbanas que atendam diferentes faixas de renda.

O PDE também definiu restrições ao número de garagens consideradas nos eixos de estruturação urbana. Assim, passa a ser admitida até uma vaga por unidade residencial e uma vaga para cada 70 m^2 de área construída nos empreendimentos não residenciais. As vagas excedentes passam a ser computáveis como área construída e passíveis de cobrança de outorga onerosa em empreendimentos que se situem ao longo dos eixos de estruturação. Nesse sentido, promove-se o desincentivo ao uso do automóvel particular motorizado, incentiva-se a utilização dos transportes públicos de massa e amplia-se o espaço construtivo útil nos eixos de estruturação urbana (LEITE *et al*., 2015).

O incentivo ao adensamento construtivo nos eixos de transporte só é possível se houver, em contrapartida, restrições ao adensamento construtivo dispersos pela cidade. Nesse sentido, o Plano Diretor determinou limitações à verticalização e limites de adensamento fora dos eixos de transporte público de massa. As zonas mistas e zonas de centralidades, áreas que contemplam bairros de classe média e alta envolvendo áreas residenciais e de usos mistos, têm como limite equivalente ao coeficiente de aproveitamento de duas vezes o tamanho do terreno, restringindo a produção imobiliária e o adensamento construtivo no

miolo dos bairros. Nessas áreas também foram definidos limites de gabarito (altura) dos edifícios em 28 m nas zonas mistas e 48 m nas zonas de centralidade (SÃO PAULO, 2014).

Por fim, é preciso destacar as operações urbanas consorciadas (OUC), que visam incentivar e orientar o adensamento em vazios urbanos na orla ferroviária e terrenos de antigas fábricas abandonadas em regiões centrais dotadas de infraestrutura. As OUC precisam de aprovação em lei específica, podendo ter regras de adensamento superiores ao adensamento máximo permitido na cidade (CAmax4). Nas operações urbanas, certificados de potencial adicional de construção (Cepacs) são leiloados arrecadando recursos antecipadamente para reinvestimento em obras públicas e intervenções para a transformação e valorização imobiliária dessa área previamente delimitada, sendo que 25% dos recursos arrecadados deveriam ser investidos em habitação de interesse social no entorno.

O instrumento das operações urbanas consorciadas é controverso. Se, de um lado, há uma orientação ao mercado imobiliário para que promova adensamento construtivo em áreas de vazios urbanos dotados de infraestrutura, estando de acordo com os princípios de uma cidade compacta; de outro, as operações urbanas concentram investimentos públicos em áreas restritas do território do município já valorizadas, em detrimento de investimentos na cidade como um todo, privilegiando os interesses de empreiteiras, incorporadoras, construtoras de obras privadas e proprietários fundiários dessas regiões, que têm seus imóveis supervalorizados em processos de desapropriação (NOBRE, 2019).

A Tabela 1 sistematiza os instrumentos urbanísticos do Plano Diretor que visam operacionalizar as diretrizes e os princípios relacionados a um modelo de cidade compacta.

Tabela 1 | Cidade compacta e o PDE 2014

Princípios	*Diretrizes*	*Instrumentos*		*Aplicabilidade*
Desenvolvimento urbano orientado pelos eixos de transporte de massa	Adensamento Construtivo	CA base 1 em toda a cidade	CA máximo 4 Descontos OODC	Autoaplicáveis nos eixos
	Adensamento Populacional	Cota-parte máxima	Limite ao tamanho médio de apartamentos	Autoaplicáveis nos eixos
	Usos mistos do solo urbano	Fachada ativa	Comércio e serviços no térreo de edifícios	Autoaplicáveis nos eixos
	Ampliação dos eixos de estruturação	Fundurb: 30% para infraestrutura de transporte público e mobilidade ativa		Orientação política
	Qualificação da quadra	Quadras menores Restrições aos muros Calçadas maiores Recuos menores dos edifícios		Autoaplicáveis nos eixos
Desincentivo ao uso de transportes motorizados individuais	Limites de garagens	Limites de garagem como áreas não computáveis no total da área construída		Autoaplicáveis nos eixos
Desenvolvimento urbano em áreas subutilizadas dotadas de infraestrutura	Adensamento construtivo na orla ferroviária e antigas áreas industriais	Operações urbanas consorciadas com áreas delimitadas no PDE		Legislação específica
		Projetos de intervenção urbana		

Fonte: Elaboração própria.

A maior parte dos instrumentos relacionados ao modelo de uma cidade compacta foi definida como instrumentos regulatórios autoaplicáveis. Essa característica confere maior estabilidade à implementação dessas diretrizes. No entanto, várias dessas regulamentações foram objeto de disputas de interesses na arena regulatória com tentativas de alteração da Lei de Zoneamento no final de 2017 e início de 2018, na gestão Doria, e, posteriormente, em novembro de 2019, na gestão Bruno Covas. Particularmente em 2017, os principais instrumentos que foram objeto de pressão por parte de incorporadoras imobiliárias e que afetam os princípios da cidade compacta são: i) descontos na outorga onerosa do direito de construir; ii) maior flexibilidade nas regras para garagens nos eixos de transporte público; iii) extinção dos limites de altura de edifícios nos miolos dos bairros (SMUL, 2017).

A demanda por descontos na compensação financeira paga pelo direito de construir implica na redução dos recursos do Fundurb, que seriam distribuídos em investimentos em toda a cidade, particularmente em habitação social e na mobilidade urbana, contrariando os objetivos de redução das iniquidades socioterritoriais, o que afeta diretamente os interesses dos movimentos sociais por moradia (SMUL, 2018b).

A extinção dos limites de altura nos miolos dos bairros, por sua vez, caminha no sentido de uma verticalização de edifícios e, potencialmente, um adensamento construtivo disperso na cidade, o que contrariaria os princípios de uma cidade compacta. Além disso, tal demanda por parte das incorporadoras imobiliárias contradiz os interesses das associações de bairro de classe média alta localizadas no chamado centro expandido da cidade, as quais têm como uma das suas principais reivindicações a manutenção de bairros horizontais de baixa densidade construtiva e populacional nessas regiões, justificadas em termos de proteção das características da localidade e direitos de vizinhança (SMUL, 2018b). As demandas pela manutenção de baixa densidade construtiva e populacional na região central dotada de infraestrutura urbana consolidada e alta oferta de empregos formais, porém, também contrariam os princípios de uma cidade compacta.

Em relação aos investimentos na cidade, durante a gestão Covas, em 2019, observaram-se duas alterações nos critérios definidos no Plano Diretor para destinação mínima dos recursos do Fundurb: i) permitiu-se a utilização do recurso para construção de unidades habitacionais pelo poder público, para além do uso restrito da mera aquisição de terrenos, como definido inicialmente; ii) possibilitou-se a utilização dos recursos no sistema viário em sentido amplo. No primeiro caso, a alteração legislativa corrigiu uma distorção tendo em vista que o foco é garantir a maior oferta de HIS. Já no segundo, a alteração desvirtua o propósito de investimentos em mobilidade ativa e corredores de ônibus, tendo em vista que os recursos para essas áreas passam a competir com obras de infraestrutura viária.

O Plano Diretor previa a implementação de 208 km de corredores de ônibus até 2016, além dos atuais 160 km preexistentes. Até 2025 previa-se implementar mais 322 km totalizando 690 km ao todo. No entanto, apenas 11,8 km foram implementados, sendo os maiores atrasos nas áreas de menor renda nas zonas leste e norte (TOMASIELLO *et al*., 2021). Tendo em vista que as áreas de maior densidade populacional ocorrem na periferia, dadas as contradições históricas da cidade, a dificuldade na ampliação de transportes públicos eficientes para essas regiões evidencia o enorme desafio para orientar a transformação urbana rumo a um modelo de cidade compacta (SOMEKH; MILITELLI, 2021).

4 ADAPTAÇÃO SUSTENTÁVEL

A noção de adaptação sustentável parte do pressuposto de que o desenvolvimento deve promover simultaneamente adaptação local aos efeitos das mudanças climáticas, no contexto urbano, com medidas que contribuam para a equidade social e integridade ambiental, dois pilares do desenvolvimento sustentável (BROWN, 2011). A adaptação aos efeitos das mudanças climáticas é entendida como processos de ajustamentos para antecipar impactos e reduzir vulnerabilidades relacionados à variabilidade climática, no âmbito local/regional (IPCC, 2007).

Nesse sentido, intervenções para a adaptação sustentável devem abordar simultaneamente ações no curto e no longo prazo, de modo a promover a gestão do risco climático ao mesmo tempo em que se busca a redução da pobreza e das vulnerabilidades (EAKIN *et al*., 2014).

Assim, a gestão dos riscos está associada a uma abordagem específica da capacidade adaptativa que leva em consideração aspectos mais pontuais relacionados à capacidade de antecipar, identificar e responder a um determinado risco (AGRAWAL; LEMOS, 2015). Por outro lado, a abordagem de capacidade adaptativa genérica é convergente com a promoção do desenvolvimento sustentável em uma perspectiva que visa o desenvolvimento que contribua tanto para a redução das desigualdades sociais como para a promoção da sustentabilidade ambiental (BROWN, 2011; DI GIULIO *et al.*, 2016).

Nossa análise se concentra no desenho da política habitacional e política de gestão dos riscos pactuadas no Plano Diretor, levando em consideração, particularmente, a capacidade de intervenções na morfologia urbana, relacionada à política de desenvolvimento urbano em promover a redução de desigualdades socioterritoriais no município, bem como a redução de vulnerabilidades e intervenções em áreas de risco (Quadro 2).

No contexto brasileiro, de acordo com a Política Nacional de Defesa Civil (2012), União, estados e municípios têm o dever de adotar medidas para a redução de risco de desastres, cabendo aos municípios a identificação das áreas de risco. Desse modo, os municípios são responsáveis pela elaboração de cartas geotécnicas de aptidão à urbanização que forneçam orientações sobre as fragilidades e potencialidades do território a partir de suas características físicas, dos processos que geram situações de riscos e das formas de uso e ocupação do solo existentes que devem ser levadas em consideração na Lei de Zoneamento a fim de garantir a segurança de novos parcelamentos do solo (NOGUEIRA; CANIL, 2017).

A elaboração de um Plano Municipal de Redução de Riscos (PMRR), por sua vez, seria uma ferramenta capaz de realizar a gestão dos riscos na cidade de maneira sistêmica e integrada, visto que seu objetivo é mapear áreas de riscos geológico e hidrológico, definir custos das ações necessárias e possíveis fontes de recursos, a fim de subsidiar programas de recuperação ambiental, medidas de regularização fundiária, ações estruturais e ainda eventuais realocações (MIRANDOLA *et al*., 2015).

A regularização fundiária e a oferta de habitação de interesse social voltada para as faixas de menor renda da população, onde se concentra o maior déficit habitacional, são medidas convergentes com os propósitos de reduzir as desigualdades socioterritoriais, incluir a população de baixa renda em áreas urbanizadas e contribuir para a contenção do espraiamento urbano. A viabilização de projetos habitacionais, no entanto, enfrenta barreiras financeiras para sua efetiva implementação sendo relevante considerar a existência de mecanismos institucionais que garantam recursos regulares voltados para a habitação (RIBEIRO; SANTOS, 2016).

Quadro 2 | Princípios para aumento da capacidade adaptativa e resiliência urbana

- Restringir o espraiamento urbano;
- Elaborar cartas geotécnicas de aptidão à urbanização;
- Evitar a instalação de infraestruturas urbanas em áreas de risco;
- Restringir o desenvolvimento urbano em áreas propensas a inundações e deslizamentos;
- Promover oferta de habitação de interesse social e regularização fundiária;
- Desenvolver construções para reassentamento de populações em áreas de risco;
- Elaborar Planos Municipais de Redução de Riscos que contenham mapeamentos das áreas de risco com a orçamentação dos recursos necessários para medidas estruturais de contenção;
- Melhorar os sistemas de drenagem;
- Realizar a manutenção regular de infraestruturas.

Fonte: Elaboração própria.

O Plano Diretor 2014 regulamenta um conjunto de instrumentos que visa promover a redução das desigualdades urbanas socioterritoriais, garantindo simultaneamente a redução das vulnerabilidades e o aprimoramento da gestão de riscos socioambientais. Nesse sentido, destacam-se: i) a previsão de recursos regulares para habitação de interesse social; ii) reserva de terras destinadas à construção de novas moradias ao público de baixa renda em áreas dotadas de infraestrutura urbana consolidada; iii) instrumentos urbanos para coibir a ociosidade dos imóveis urbanos e dar função social à propriedade; iv) urbanização de favelas, regularização fundiária de assentamentos urbanos precários e reassentamento de pessoas que vivem em áreas de risco e áreas de preservação ambiental.

Os recursos arrecadados com a outorga onerosa são destinados ao Fundo Municipal de Desenvolvimento Urbano (Fundurb), dos quais 30% devem ser alocados para habitação de interesse social (HIS), e proporcionam recursos regulares extraorçamentários para investimento no município como um todo, visando à redistribuição da mais-valia urbana (FRANCO *et al*., 2015). Nas Operações Urbanas Consorciadas, por sua vez, 25% dos valores arrecadados devem ser destinados para HIS em assentamentos precários do seu entorno. Nesse último caso, porém, os valores arrecadados restam concentrados em uma determinada região da cidade (NOBRE, 2019).

A cota de solidariedade, por sua vez, é um instrumento urbanístico que determina que os grandes projetos imobiliários (acima de 20 mil m^2) devem produzir habitação de interesse social (HIS) ou doar recursos equivalentes a 10% de área do seu empreendimento para HIS (ALBUQUERQUE *et al*., 2015).

Além da previsão de recursos regulares para habitação, o Plano Diretor 2014 ampliou a delimitação de zonas especiais de interesse social (ZEIS), envolvendo: i) regularização fundiária e urbanização de favelas (ZEIS 1); ii) oferta habitacional em vazios urbanos (ZEIS 2); iii) produção e reforma de moradias em terrenos ou imóveis subutilizados em áreas com infraestrutura urbana consolidada, serviços e oferta de empregos formais, geralmente localizadas na região central da cidade (ZEIS 3); iv) produção de HIS em áreas de proteção de mananciais, que sejam dotadas de infraestrutura urbana prévia, voltadas exclusivamente para a população transferida de áreas de risco e das margens das represas (ZEIS 4); e v) oferta de habitação para uma classe média em vazios urbanos em áreas com boa infraestrutura próximas à região central do município (ZEIS 5).

Em todas as ZEIS é permitido o adensamento construtivo equivalente a quatro vezes o tamanho do lote. Nas ZEIS 1, 2, 3 e 4, o poder público e incorporadoras privadas devem ofertar, como regra, no mínimo 60% das unidades habitacionais do edifício para faixa de renda até três salários mínimos (HIS 1). As unidades habitacionais restantes podem ser ofertadas seguindo os seguintes parâmetros: mais 20% para HIS 1 (até três salários mínimos) ou HIS 2 (3 a 6 salários mínimos) e os restantes 20% para habitação de mercado popular (HMP), voltado para o público com renda de 6 a 10 salários mínimos. Esse foi um importante avanço no PDE 2014 relacionado à demanda de movimentos sociais por moradia, e visa atender à maior demanda por habitação que se concentra nas camadas de renda mais baixa.

A delimitação de áreas classificadas como ZEIS 5, no entanto, aplica regras diferentes para a oferta de unidades habitacionais por faixa de renda, atendendo a uma demanda de setores do mercado imobiliário que atuam nesse segmento e que pressionaram para uma maior percentagem de destinação para o público com renda entre 6 a 10 salários mínimos. Nas ZEIS 5, portanto, 40% podem ser destinados para HIS 1 ou HIS 2 e até 60% podem ser destinados para HMP.

Em relação aos instrumentos que visam dar função social à propriedade e combater a ociosidade de imóveis urbanos, São Paulo conta, desde 2010, com legislação que regulamenta o instrumento de Parcelamento, Edificação ou Utilização Compulsória (Peuc) e seus sucedâneos, o IPTU progressivo no tempo e Desapropriação com pagamento em títulos mobiliários. No entanto, sua aplicação era falha, não gerando obrigações legais aos proprietários notificados. O Plano Diretor de 2014 estabeleceu regras mais claras e ampliou as áreas passíveis de aplicação do PEUC em áreas qualificadas da cidade incluindo ZEIS 2, 3 e 5, áreas de operações urbanas consorciadas, subprefeituras da Sé e Mooca, áreas de influência dos eixos de estruturação da transformação urbana, áreas urbanizadas, bem como glebas maiores que 20 mil m^2 em áreas periféricas da cidade (BONDUKI; ROSSETTO, 2018).

Em relação aos princípios de ampliação da capacidade adaptativa específica, ou seja, medidas que contribuem para redução e gerenciamento de riscos, vale destacar a Carta Geotécnica de aptidão à urbanização e o Plano Municipal de Redução de Riscos. A Carta Geotécnica contribui para impedir construções formais em áreas propensas ao risco geológico no momento do licenciamento da obra. Apesar de ser importante instrumento de planejamento e informação, a Carta Geotécnica não regula as ocupações informais, que são a maioria das habitações em áreas de risco no município.

O Plano Municipal de Redução de Riscos, por sua vez, foi previsto no Plano Diretor como um instrumento que deveria ser elaborado de maneira detalhada envolvendo, além da identificação das áreas e populações vulneráveis aos riscos geológicos e hidrológicos, estimativas orçamentárias sobre os recursos necessários com ações estruturais (como contenção de encostas, por exemplo) e/ou realocação de população em situação de risco a fim de reduzir as vulnerabilidades e abordar de forma integrada e sistêmica os riscos na cidade. No entanto, passados sete anos da promulgação do PDE, pouco se avançou na elaboração desse importante instrumento de planejamento e gestão dos riscos na cidade.

A Tabela 2 sistematiza os principais instrumentos presentes no PDE convergentes com as diretrizes de um modelo de desenvolvimento urbano que visa à redução das desigualdades e vulnerabilidades socioterritoriais.

Tabela 2 | Adaptação sustentável

Princípios	*Diretrizes*	*Instrumentos*		*Aplicabilidade*
Função social da cidade	Recursos regulares para habitação social	CA base 1 em a toda cidade Pagamento de contrapartidas acima do CA base Cota de solidariedade Fundo de desenvolvimento urbano		Regulamentação autoaplicável
	Reserva de terras para HIS em áreas qualificadas	Delimitação de ZEIS no PDE Maior adensamento permitido		
Função social da propriedade	Urbanização de favelas	ZEIS 3	HIS 1 = 60%	Regulamentação autoaplicável
		ZEIS 1, 2, 4	HIS 2 = 40%	
		ZEIS 5	HIS 1 e HIS 2 = 50%	
Redução de desigualdades socioespaciais		Plano Municipal de Habitação		Lei específica
	Regulação fundiária	Fundurb: 30% para HIS		Alocação por decisão política
	Ampliar oferta de equipamentos urbanos em áreas vulneráveis	Parcelamento, Edificação ou Utilização Compulsória (Peuc) IPTU progressivo no tempo		Facultativa pelo poder público
		Plano de rede de equipamentos urbanos e sociais		Alocação por decisão política
	Impedir edificações em áreas de risco	Carta Geotécnica		Instrumento autoaplicável
Redução de riscos de deslizamentos	Obras de contenção Reassentamentos de populações em áreas de risco	ZEIS 4 Recursos do FUNDURB		Alocação por decisão política
		Plano Municipal de Redução de Riscos (PMRR)		Plano municipal intersecretarial

Fonte: Elaboração própria.

Como mencionado anteriormente, a arena regulatória da política urbana foi objeto de pressão por parte de incorporadoras imobiliárias, durante a gestão Doria. Entre as principais demandas que influenciariam os princípios de adaptação sustentável envolvendo a redução das desigualdades socioterritoriais se destacam: i) redução nos valores das contrapartidas financeiras pagas pelo direito de construir; ii) eliminação da cota de solidariedade que obriga os grandes empreendimentos imobiliários a produzirem ou doarem recursos para habitação de interesse social, em termos percentuais ao seu empreendimento; iii) redução do percentual obrigatório de fornecimento de unidades habitacionais destinadas à baixa renda, dos atuais mínimos de 60% para um pareamento (50% e 50%) da proporção de oferta de HIS 1, e outras modalidades destinadas a faixas de renda mais elevadas (SMUL, 2017).

Essas demandas de alteração de instrumentos regulatórios vão ao encontro dos interesses de aumento na lucratividade por parte de incorporadoras imobiliárias. Porém, teriam como consequência a redução nos recursos a serem distribuídos em toda a cidade, sobretudo destinados ao provimento de habitação social. Além disso, tais demandas, se concretizadas, reduziriam a oferta de HIS para as faixas de menor renda, onde se concentra o déficit habitacional, contrariando diretamente as demandas de movimentos sociais por moradia.

A forte oposição empreendida tanto por parte de associações de bairros de classe média alta do centro expandido da cidade quanto por movimentos sociais por moradia conseguiu barrar o processo de revisão extemporânea da Lei de Zoneamento. Tal oposição se manifestou por meio de mobilizações nas reuniões de consulta pública, elaboração de uma carta aberta ao prefeito e principalmente a subscrição de uma petição judicial para suspender o processo de revisão da legislação que contrariava seus interesses, alegando descumprimento dos ritos formais de tramitação do projeto de lei (SMUL, 2018a).

Na gestão Covas, por sua vez, houve recuo em relação ao desconto na outorga onerosa e cota de solidariedade. Além disso, o poder público propôs soluções mediadoras em relação a essas demandas conflitantes: i) indicou que a cota de solidariedade pudesse ser voluntária para empreendimentos menores de 500 m^2 com a contrapartida de ganhos em potencial construtivo; ii) e manteve a relação inicial de 60% HIS 1 e 40% outras modalidades, no entanto, permitindo maior índice de aproveitamento construtivo em ZEIS sem cobrança da outorga onerosa, desde que 20% das HIS (adicionais) fossem voltadas para as faixas até três salários mínimos (SMUL, 2019).

5 ADAPTAÇÃO BASEADA EM ECOSSISTEMAS

Os princípios orientadores da adaptação baseada em ecossistemas (AbE) (Quadro 3) visam a realização de iniciativas em infraestrutura verde, distribuídas no município, que gerem cobenefícios ambientais, sociais, econômicos e a promoção de bem-estar e saúde, ao mesmo tempo em que proporcionam melhoramento da drenagem urbana, redução de vulnerabilidades geológicas aos efeitos de eventos climáticos extremos e redução de ilhas de calor no tecido urbano. Além disso, contribuem para a promoção do controle do espraiamento urbano, proteção de mananciais produtores de água, proteção de ecossistemas com cinturões verdes nas áreas periféricas da cidade e promoção de agricultura urbana e periurbana (BRINK *et al*., 2016; GENELETTI; ZARDO, 2016; LAFORTEZZA *et al*., 2013; WAMSLER *et al*., 2014).

Os desafios de adaptação das cidades brasileiras podem ser enfrentados com menor custo financeiro e maiores ganhos ambientais com a implementação de soluções de infraestrutura verde que permitem estruturar sistemas alternativos de drenagem, combinando soluções de baixo impacto, como corredores verdes urbanos, reflorestamentos de encosta e ruas verdes em vez de medidas convencionais de engenharia – infraestrutura cinza (HERZOG; ROSA, 2010).

Parques urbanos distribuídos em vários bairros pela cidade, parques lineares às margens dos córregos, arborização de ruas e avenidas e incentivos para promoção de espaços verdes nos empreendimentos imobiliários privados são medidas que contribuem para: i) reduzir a impermeabilização dos solos, diminuindo o potencial de inundações, ii) promover resfriamento microclimático, reduzindo o efeito de ilha de calor, iii) reduzir a poluição sonora e iv) contribuir para qualificar a paisagem urbana, desempenhando funções múltiplas: ecológicas, estéticas, educacionais, de sociabilidade e de lazer (JACOBI *et al*., 2015; LAFORTEZZA *et al*., 2013).

Por sua vez, a conservação e restauração dos cinturões verdes nas zonas periféricas da cidade com florestas urbanas e o incentivo à produção agrícola urbana e periurbana são iniciativas que contribuem simultaneamente para proteger e preservar as áreas de mananciais, buscando promover a melhoria da qualidade das águas nos reservatórios de abastecimento da cidade, fomentar os serviços ecossistêmicos produtores de água, conter o espraiamento urbano e promover meios de subsistência às comunidades locais, oportunidades de turismo e segurança alimentar (BRINK *et al*., 2016; CHU *et al*., 2017).

Quadro 3 | Princípios sobre adaptação baseada em ecossistemas

- Controlar o espraiamento urbano;
- Proteger mananciais produtores de água;
- Redimensionar os sistemas de drenagem;
- Implantar praças alagáveis e ampliar áreas permeáveis;
- Ampliar a arborização urbana;
- Fomentar a implementação de parques urbanos distribuídos pela cidade;
- Incentivar a implantação de telhados verdes e hortas urbanas;
- Incentivar as agriculturas urbana e periurbana;
- Criar florestas urbanas e infraestruturas verdes;
- Proteger ecossistemas com a criação de cinturões verdes.

Fonte: Elaboração própria.

O Plano Diretor de 2014 reconhece tratamento destacado ao gerenciamento, conservação e restauração de áreas verdes no texto da lei. Entre os principais pontos da agenda de sustentabilidade ambiental e contenção do espraiamento urbano no Plano Diretor vale destacar a delimitação de zonas rurais no município, incentivos à agricultura orgânica, ao ecoturismo e ao pagamento por serviços ambientais (FRANCO *et al*., 2015).

Com essas medidas, o Plano Diretor objetiva promover simultaneamente a agricultura sustentável no cinturão verde da cidade ampliando a oferta de produtos agroecológicos; gerar e manter empregos na área rural, evitando a evasão populacional na região; dificultar o avanço de ocupações irregulares ao manter a característica rural na região; e preservar as nascentes contribuindo para a qualidade dos mananciais do entorno, principalmente na zona sul de São Paulo. Assim, caminha-se no sentido de qualificar o valor de uso nas áreas de proteção ambiental para conter a expansão urbana não simplesmente restringindo o uso urbano, mas principalmente incentivando o uso sustentável nessas áreas (NAKAMURA; MARCOS, 2021).

No espaço urbano, entre as principais propostas de qualificação ambiental, vale destacar a delimitação feita no Plano Diretor de áreas para criação de parques distribuídos pelo município, a previsão de criação de um fundo específico para a implementação e gestão de parques, bem como o plano de arborização da cidade.

Foram demarcadas 167 áreas (públicas e privadas) no Plano Diretor voltadas para a implantação de parques (urbanos e naturais) que vêm a se somar aos 121 parques existentes à época. A demarcação dessas áreas como zonas especiais de proteção ambiental (Zepam) restringe o aproveitamento construtivo inviabilizando empreendimentos imobiliários formais nessas áreas. Por outro lado, seus proprietários podem receber recursos do mecanismo de pagamento por serviços ambientais, ou, ainda, podem transferi-lo ao município recebendo em troca valores monetários (BONDUKI, 2014).

Outro mecanismo relevante que acompanha o conjunto de inovações da lei urbanística e ambiental na cidade é a denominada quota ambiental. Trata-se de um instrumento urbanístico regulatório que estabelece regras para qualificação ambiental no âmbito do lote para novas edificações a partir de 500 m^2 de área em determinadas regiões do município, conforme definido pela Lei de Parcelamento, Uso e Ocupação do Solo do município (Lpuos) (SÃO PAULO, 2016).

O objetivo principal da quota ambiental é promover a criação de espaços verdes em projetos de construção em determinadas regiões da cidade visando ao aumento da permeabilidade do solo e aumento da cobertura vegetal no âmbito do lote, a fim de reduzir os efeitos de ilha de calor e

proporcionar melhor drenagem de águas pluviais, contribuindo para minimizar efeitos de alagamentos e/ou inundações na cidade (CAETANO, 2016; MALERONKA, 2015).

A Tabela 3 destaca os principais instrumentos, políticas e diretrizes presentes no PDE associados ao modelo de desenvolvimento urbano baseado nos princípios de adaptação baseada em ecossistemas.

Tabela 3 | Adaptação baseada em ecossistemas

Princípios	*Diretrizes*	*Instrumentos*	*Aplicabilidade*
Controle de espraiamento urbano	Incentivar agricultura urbana e periurbana	Delimitação da área rural no zoneamento	Regulação autoaplicável
		Plano de desenvolvimento rural sustentável	Diretriz Programática (SMDU e SVMA)
Criação de cinturões verdes nas periferias da cidade	Delimitar áreas prestadoras de serviços ambientais	Pagamento por serviços ambientais (editais)	Diretriz Programática (SVMA e SMDU)
Proteção de mananciais produtores de água	Preservar florestas urbanas	Plano Municipal de Conservação e Recuperação da Mata Atlântica	Diretriz Programática
Redução de riscos de inundação	Ampliar áreas alagáveis e áreas permeáveis	Quota ambiental	Regulação autoaplicável (Lpuos)
		Delimitação de áreas para criação de parques distribuídos pela cidade	Delimitações no Plano Diretor
		Recursos para criação de parques	Fundurb e Fundo específico
Redução de ilhas de calor	Arborização urbana	Plano Municipal de Arborização Urbana	Diretriz Programática (SVMA, SMDU, SMSUB)

Fonte: Elaboração própria.

O reconhecimento da zona rural do município de São Paulo no Plano Diretor, por si só, gerou possibilidades aos agricultores, sobretudo da zona sul, de acessarem crédito rural e mercados para produtos agroecológicos, além de ser uma medida para contenção do espraiamento urbano e manutenção de áreas verdes (NAKAMURA; MARCOS, 2021). Nessa mesma linha, o instrumento de Pagamento por Serviços Ambientais, proposto pelo Plano Diretor, contribui para a preservação ambiental em áreas que mantenham, restabeleçam ou recuperem os ecossistemas, incluindo a proteção aos mananciais (SEPE; PEREIRA, 2015).

A política ambiental municipal definida pelo Plano Diretor é formada majoritariamente por diretrizes programáticas e, portanto, a sua efetiva implementação é dependente de vontade política e alocação de recursos, sobretudo os recursos da Secretaria Municipal do Verde e do Meio Ambiente de São Paulo (SVMA), que se encontram em disputa com outras secretarias (DI GIULIO, 2020). Nesse contexto, a política ambiental prevista no Plano Diretor foi a que menos avançou desde a promulgação do PDE, com baixa implementação de novos parques (SÃO PAULO, 2019b) e a observação de ampliação do espraiamento urbano à custa do desmatamento ilegal nas florestas periurbanas (NATALINI, 2020).

Em relação à arena regulatória, a quota ambiental foi objeto de tentativa de alteração em 2018 visando alterar as regras de abrangência do instrumento de 500 m^2 para 1.000 m^2 (SMUL, 2017). Essa proposta parte de uma demanda de produtoras imobiliárias visando reduzir custos e ampliar o aproveitamento construtivo. No entanto, teria como resultado uma diminuição no número de novos edifícios com

incentivos para adoção de procedimentos construtivos sustentáveis o que acarretaria uma redução da capacidade de adaptação, aumento de inundações, enxurradas, alagamentos e aumento de ilhas de calor, ou seja, o interesse privado em maximizar o lucro por parte de produtoras imobiliárias afetaria negativamente o interesse público. Em 2019, a gestão Covas recuou nessa proposta, mas permitiu maior flexibilização do instrumento envolvendo outras formas de qualificação ambiental (SMUL, 2019).

6 CONSIDERAÇÕES FINAIS

O artigo teve como propósito mapear instrumentos regulatórios de política urbana capazes de operacionalizar os objetivos de uma transformação urbana rumo a um modelo de cidade compacta, que visa redução das desigualdades socioterritoriais, aumento da resiliência e qualificação ambiental. Nesse contexto, observou-se que o pacto sociopolítico definido pelo Plano Diretor paulistano trouxe algumas inovações convergentes com esses princípios e diretrizes.

Um dos principais avanços se deu em relação à aplicação de instrumentos regulatórios autoaplicáveis nos eixos de transportes coletivos de média e alta capacidade para orientação visando princípios de uma cidade compacta. Além disso, houve a ampliação de recursos extraorçamentários para investimentos na cidade, particularmente em habitação social e mobilidade urbana.

No entanto, nas duas gestões seguintes à aprovação do PDE, a arena regulatória foi alvo de pressões principalmente por parte de produtoras imobiliárias que, visando aumento nas margens de lucro de seus empreendimentos, buscaram flexibilizar regramentos que afetariam negativamente os objetivos de uma cidade compacta, de redução de iniquidades socioterritoriais e qualificação ambiental.

Entre as principais demandas das incorporadoras imobiliárias na arena regulatória que afetariam os objetivos de uma cidade compacta, destacam-se: i) descontos nas contrapartidas financeiras pagas pelo direito de construir acima do índice básico; ii) eliminação dos limites à verticalização de edifícios nos miolos dos bairros; e iii) flexibilização das vagas de garagem computáveis como área construída em novos edifícios nos eixos de transportes públicos.

Em relação às demandas das incorporadoras que afetariam negativamente os objetivos de redução de iniquidades socioterritoriais e aprimoramento da resiliência urbana, destacam-se: i) descontos na outorga onerosa, que reduziria os recursos para investimentos de forma abrangente na cidade, incluindo-se recursos para habitação social e realocação de população em áreas de risco; e ii) redução da porcentagem obrigatória de oferta de unidades habitacionais para baixa renda em ZEIS.

Por fim, em relação aos instrumentos regulatórios de política urbana associados à qualificação ambiental em novos edifícios, incorporadoras imobiliárias pressionaram para que a sua aplicação deixasse de ser obrigatória para edificações inferiores a mil m^2 o que inviabilizaria os objetivos do instrumento.

Tais propostas de alteração na Lei de Zoneamento, no entanto, foram barradas por uma coalizão envolvendo associações de bairro de classe média e de movimentos sociais de moradia que viram nessas tentativas de alteração extemporânea da lei potenciais retrocessos no pacto sociopolítico estabelecido no Plano Diretor, e que afetariam de diferentes formas os seus interesses e visões sobre desenvolvimento urbano.

Vale destacar também que o Poder Executivo, em 2019, foi fiador de duas alterações no Plano Diretor sobre a forma de utilização dos recursos do Fundurb: i) permitiu que os recursos sejam utilizados também para ofertar habitações sociais, para além da mera aquisição de terrenos, como previsto inicialmente, corrigindo uma distorção; e ii) possibilitou que os recursos destinados à mobilidade urbana sejam utilizados irrestritamente em infraestrutura, desvirtuando o propósito inicial de aplicação exclusiva em

infraestrutura para o transporte público e para mobilidade ativa, áreas que precisariam ser priorizadas, sobretudo nas regiões periféricas, seguindo objetivos de uma cidade com maior eficiência energética nos transportes, de baixa emissão de carbono e mais interconectada.

A agenda ambiental e a agenda de redução de riscos de desastres, ambas mais diretamente relacionadas aos objetivos de um modelo de cidade segura, resiliente e sustentável, foram as que menos avançaram nesse período. Apesar de constarem várias previsões no Plano Diretor sobre essas agendas, a maior parte dos dispositivos previstos em lei é fundamentalmente composta por diretrizes programáticas que, nessa condição, ficam suscetíveis ao comprometimento político e alocação de recursos em momento futuro no tempo.

Em síntese, o pacto sociopolítico definido pelo Plano Diretor de 2014 não é estável e no decorrer das duas gestões seguintes à sua aprovação verificaram-se pressões que concorreram para descaracterizar os seus objetivos, priorizando sobretudo os interesses de incorporadoras imobiliárias.

Reservadas as peculiaridades do município de São Paulo, tais como um mercado imobiliário diversificado, pujante e aquecido; movimentos sociais por moradia historicamente organizados e atuantes; e uma elite de classe média alta estabelecida historicamente na região do centro expandido do município com demandas por baixas densidades construtiva e populacional, acredita-se que os resultados de pesquisa ora apresentados podem servir como referência para inspirar estudos sobre os desafios para a transformação sustentável em outros contextos urbanos.

NOTAS

1 | Lei 10.257, de 10 de julho de 2001, estabelece diretrizes gerais da política urbana e dá outras providências.

2 | As duas propostas de alteração da lei ocorreram na gestão eleita para governar entre 2017-2020, pela coalizão político-partidária (PSDB) de oposição à gestão Haddad (PT) que governou entre 2013-2016 e que promulgou o PDE em 2014. João Doria venceu as eleições contra a candidatura de reeleição de Haddad, mas renunciou ao cargo em março de 2018 para disputar as eleições para governador do estado de São Paulo, assumindo assim a prefeitura o seu vice, Bruno Covas, filiado também ao PSDB.

3 | Disponível em: https://www.prefeitura.sp.gov.br/cidade/secretarias/licenciamento/desenvolvimento_urbano/dados_estatisticos/ Acesso em: 16 out. 2020.

4 | Inciso II do art. 340 do Plano Diretor de São Paulo (SÃO PAULO, 2014).

5 | Inciso I do art. 340 do Plano Diretor de São Paulo (SÃO PAULO, 2014).

6 | Essas regras de aplicação dos recursos do Fundurb sofreram alterações importantes dadas pela Lei 17.217, de 23 de outubro de 2019, como será discutido à frente.

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Municipal environmental management and regional conservation in eastern Amazon: perceived performance by public agents in the Pará state, Brazil

Gestão ambiental municipal e conservação regional na Amazônia Oriental: desempenho percebido por agentes públicos no estado do Pará, Brasil

Benedito Evandro Barros da Silva [1]

Cláudia Azevedo-Ramos [2]

Hilder André Bezerra Farias [3]

[1] PhD in Socioenvironmental Development, Environmental Analyst, Secretaria Estadual de Meio Ambiente e Sustentabilidade do Pará (Semas/PA), Marabá, Brazil
E-mail: evandroourem@yahoo.com.br

[2] PhD in Ecology, Professor, Núcleo de Altos Estudos Amazônicos (NAEA),Universidade Federal do Pará, Belém, Brazil
E-mail: claudia.azevedoramos@gmail.com

[3] PhD in Economics, Adjunct Professor, Department of Economics, Universidade Federal do Pará, Belém, Brazil
E-mail: hilder@ufpa.br

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ABSTRACT

Public agents play a key role in municipal environmental management (MEM) under decentralised regimes. This study aimed to evaluate the MEM through the combined perception of municipal agents and the municipal performance previously calculated by secondary data in Pará, Brazil. A questionnaire with a 5-point Likert scale was applied to environmental agents. The respondents (n = 75) from 53 municipalities were divided into poorly performing and well-performing municipalities. The perception of agents from poorly performing municipalities was more optimistic than shown by empirical data. Agents from well-performing municipalities prioritised "economic issues" as significant threats to management over the "institutional capacity" chosen by the other group, indicating a broader view of the reality. As the perception over land-use practices was vital to differentiate the agents from different groups, we concluded for the use of mixed monitoring methods and feedback information for agents for a better MEM, focusing on five variables (Rural environmental register – CAR, in Portuguese acronym; degraded area; deforested area; rural credit; and abandoned pasture) that differentiated the municipalities.

Keywords: Amazon. Environmental performance. Perception. Public management. Sustainability.

RESUMO

Os agentes públicos desempenham um papel fundamental na gestão ambiental municipal (GAM) em regimes descentralizados. Este estudo objetivou avaliar a GAM por meio da percepção combinada dos agentes municipais e do desempenho municipal previamente calculado por dados secundários no Pará, Brasil. Um questionário com escala Likert de 5 pontos foi aplicado a agentes ambientais. Os respondentes (n = 75) de 53 municípios foram divididos em municípios com baixo e bom desempenho. A percepção dos agentes de municípios com baixo desempenho foi mais otimista do que os dados empíricos. Agentes de municípios com bom desempenho priorizaram "questões econômicas" como grandes ameaças à gestão sobre a "capacidade institucional" escolhida pelo outro grupo, indicando uma visão mais ampla da realidade. Como a percepção sobre as práticas de uso do solo foi fundamental para diferenciar os agentes de diferentes grupos, concluímos pelo uso de métodos mistos de monitoramento e informações de feedback para os agentes para uma melhor GAM, com foco em cinco variáveis (Cadastro Ambiental Rural – CAR, área degradada, área desmatada, crédito rural e pastagem abandonada) que diferenciam os municípios.

Palavras-chave: Amazônia. Desempenho ambiental. Percepção. Gestão pública. Sustentabilidade.

1 INTRODUCTION

Developing countries still face the challenges of better management of their natural environment, and environmental decentralisation in several countries since the mid-1990s has sought to address this need. However, a review of the topic in 30 countries of Africa and Latin America in the early 2000s concluded that central governments give local actors the ability to use resources but limited management powers and property rights (AGRAWAL, 2001).

In Latin America, political-administrative decentralisation is an ongoing process (FALLETI, 2010). Brazil, in particular, after a growing pressure on natural resources, intensified decentralisation reforms, especially transferring the environmental management from the central government to the municipal level (VIANA *et al*., 2016). However, political interference and local fragilities are a constant threat (SCHMITT, SCARDUA, 2015), especially for regional conservation.

In the Brazilian Amazon, environmental management by local government bodies is perceived as a challenge in the face of the substantial threats caused by the traditional model of land use and occupation, which implies the conversion of forestlands into agroecosystems (ASSUNÇÃO; ROCHA, 2014; SILVA; AZEVEDO-RAMOS, 2016). These problems are even more conspicuous in the state of Pará in the Eastern Amazon, where municipal environmental management faces unsustainable use of natural resources motivated by deforestation and land grabbing (VIANA *et al*. 2016). Pará is a recurring champion of Amazon deforestation (INPE, 2020). Land-use changes, local structural issues and the lack of effective implementation of environmental public policies hamper local environmental management (WEINHOLD; KILLICK; REIS, 2013). The diversity of forms of population occupation, including agricultural settlements, Conservation Units, Indigenous Lands and urban centres of varying sizes, reduces the distances typified in the urban-rural dichotomy, as is proper of the Amazon region (CÔRTES; ÁLVARO DE OLIVEIRA; OJIMA, 2020).

Decentralised environmental public policies have been implemented in Pará as a strategy to control local environmental impacts. Non-compliance by the municipality can be penalised by restricting public credit with consequences for the local economy (ASSUNÇÃO; ROCHA; 2014; SILVA; AZEVEDO-RAMOS, 2016). That requires more effective participation of public agents from local environmental bodies. Municipal environmental agents are key actors in mitigating local environmental problems as they are responsible for licensing and monitoring productive activities (MENDEZ; JÚNIOR, 2018). Ultimately,

poor local environmental management may threaten regional conservation in several dimensions. Therefore, these agents must understand the reality in which they are immersed and the problems that need to be faced (FERNÁNDEZ-LLAMAZARES *et al*., 2016).

Environmental perception can be defined as how an individual observes, understands, interprets and evaluates an object of reference, which may be an action, an experience, a policy or a result (BENNETT, 2016). In theory, there should be synergy between empirical results and agents' perception of environmental management performance since they are the protagonists of management planning and implementation. On the other hand, a dissociation between the calculated and perceived performance may have relevant repercussions for maintaining or correcting the adopted municipal strategy. Therefore, although conservation and governance strategies are still underestimated, research on perceptions can influence actions on scales ranging from individual initiatives to national and international policies (BENNETT, 2016).

A good perception of local public agents about the environmental management of their municipalities is crucial, therefore, to improve the planning and the implementation of public policies more efficiently (CELENTANO *et al*., 2014; DINIZ *et al*., 2015). However, the responses result from individual cognitive processes, judgments and expectations in the context of positive or negative relationships with the environment and society. By understanding this perception, as well as its sources of satisfaction and dissatisfaction, actions may be planned from the reality of that target audience (LÓPEZ-GAMERO; MOLINA-AZORÍN; CLAVER-CORTÉS, 2010). In a context of shared environmental management (e.g., between states and municipalities) as in the Brazilian Amazon, the understanding of how environmental public-agents perceive their management may become an essential ally for governments in the implementation of the environmental management system (RODRIGUES; MALHEIROS; DAGOSTIN DARÓS, 2012).

Here we offer an innovative approach combining local perceptions and objective evidence of the effectiveness of local environmental management to provide insights into understanding conservation governance outcomes. Previously, Silva, Azevedo-Ramos and Farias (2019) ranked 143 municipalities of the state of Pará in Eastern Amazon according to their environmental management performance using secondary data to calculate a performance index. Empirical data can represent an objective way of evaluating municipal management and contributing to its potential improvement. However, as desirable as it is to measure management objectively, it is necessary to recognise that mathematical models may fail to reveal nuances in the local reality better observed by humans. In this sense, the comparison between calculated performance and local agents' perception about the environmental management of their municipality represents a relevant step in the direction of better understanding and measuring environmental management.

Therefore, this study evaluated Municipal Environmental Management (MEM) through the combined perception of municipal agents and municipal performance previously calculated by secondary data in Pará, Brazil (SILVA; AZEVEDO-RAMOS; FARIAS, 2019). In this context, we addressed the following questions: 1) How do public agents evaluate the environmental management of their municipality? 2) Is there a similarity between the perception of environmental agents and the performance of municipal environmental management calculated by independent secondary data? Finally, we sought to assess the premise that the comparison between the calculated performance and the perception of local agents about the environmental management of their municipality represents a relevant step towards a better understanding and measurement of environmental management.

2 METHODS

2.1 BACKGROUND

Pará state is located in eastern Amazon, Brazil. It is the second-largest state in the country, with an area of 1,248,000 km² (3.5 times bigger than Norway) and an estimated population of 8.6 million in 2019 (IBGE, 2020). Pará has a low Human Development Index – HDI (0.646) and occupied the 11º position in Gross Domestic Product – GDP national ranking. The economy is mainly based on mining, logging, ranching and agriculture.

Silva, Azevedo-Ramos and Farias (2019) previously evaluated the environmental management performance of 143 municipalities in Pará state, from the elaboration of an index calculated through secondary empirical data based on 11 variables associated with management performance (e.g., deforestation rate; land-use changes; life quality, among others). The municipalities could then be ranked according to the performance index of environmental management and divided into performance groups (good; satisfactory; poor; very poor). In this previous study, we also evaluated the effect of 12 variables that potentially influence management (e.g., GDP – Gross Domestic Product, protected areas, rural credit) later used to verify their impact on the calculated performance index.

2.2 METHODOLOGY

In the present study, we used variables that were statistically significant on the previous study (see results; Table 3 for a shortlist; and Silva, Azevedo-Ramos and Farias (2019) for a detailed description) as a starting point for the elaboration of a perception questionnaire applied to local agents on the quality of environmental management of their municipality. Furthermore, the previous performance groups of the 143 municipalities based on the ranking of calculated performance were aggregated into two groups: good/satisfactory performing municipalities (n = 72; 50.3%) and very poorly/poorly performing municipalities (n = 71; 49.7%). The following analyses evaluated the agents' perception according to the group of municipalities to which they belong.

The target audience was the municipal agents working in the Municipal Environment Secretaries of Pará state. The methodology included 1) the assessment of agents' perceptions around the environmental management of their municipality and 2) a comparison between their perception and the calculated performance for each municipality of Pará.

The perception of municipal agents was evaluated through 360 questionnaires containing 28 questions sent electronically to the 143 municipalities of Pará using the platform Google form in 2018. The questionnaire contained a header explaining the purpose of the study and a free, prior and informed consent for participation and use of the data. Individual information was kept anonymous, and we used only aggregated data. At the same time, we explained the relevance of the research and encouraged the agents' responses by phone. Overall, the survey lasted 60 days. The agents who received the questionnaires were local decision-makers in environmental agencies and/or acted directly in municipal environmental management by appointment of municipal secretariats, which, at their discretion, consider the agent's background suitable for that function. Thus, the assessment of the agent's quality was not part of the scope of this study but rather how he/she interprets environmental management based on his/her perception. The responses of agents from the same municipality were kept as independent samples given the turnover of agents among positions.

First, using two multiple choice questions, interviewees were asked to qualitatively self-evaluate the environmental management of the municipality: a) do not know/without information; b) bad; c) fair; d) good; and e) very good. We also asked the agents to choose the significant threat to environmental

management in their municipality among the following alternatives: a) incentives for agricultural production; b) low access to communication (telephony; internet); c) low access to information on rural properties; d) low municipal, institutional capacity; e) lack of protected areas; f) high population growth; g) low municipal GDP; h) others (with description).

The agent's perception (26 questions) regarding a given variable associated with environment management in his/her municipality was assessed using a five-point Likert scale: 1 = do not know/ without information; 2 = low; 3 = fair; 4 = high; 5 = very high. We also added variables referring to the legal framework of municipal decentralisation as they describe the instruments for decision making and strengthening of local management. Cronbach's alpha was used to verify the internal coherence of the questionnaire (CRONBACH, 1951). Coherence is considered acceptable for $\alpha \geq 0.7$, which was the case in this study ($\alpha = 0.91$).

For analysis of the questionnaires on a Likert scale (LIKERT, 1932), the option 'do not know/without information' was excluded, and the others renumbered from 1 to 4. The Student's t-test ($p \leq 0.05$) was used to compare the differences between the response of each group of municipalities (good performance and poor performance) with the total mean of the questionnaire (1.981). Hypothesis tests were applied to the variables that proved most representative in the agent's perception of environmental management at the municipal level. For t-tests analyses, we considered different hypotheses for the answers depending on the agents' group. For potentially damaging impact variables to management, it is expected that agents from the poorly performing group would assign above-average values (high to very high on the Likert scale). In contrast, agents from the well-performing group would assign below average values (fair to low). In this sense, when the mean answer of a given group of municipalities is equal to the total mean of the questionnaire (1.981), nothing can be concluded regarding the differences between the agents' perceptions. On the other hand, when the mean answer of a group is lower (or ending on the group) than the total mean, there is an agreement (or disagreement, respectively) between the agents' perception and what was expected for their municipality group.

Thus, if $E(X_b)$ is the expected value of a given group of municipalities for a given question and $E(X_q)$ is the expected value of the question for all municipalities (total mean of the questionnaire), for instance, the hypotheses for the well-performing group may be summarised as follows:

H_0: $E(X_b) = E(X_q)$ (nothing can be concluded)

H_1: $E(X_b) < E(X_q)$ (agreement between the agent's perception and the expected)

H_2: $E(X_b) > E(X_q)$ (disagreement between the agent's perception and the expected).

Following the same rationale, for the poorly performing group, the signs would be reversed since the expected would be that the agents assign values above the average for variables with potentially negative impacts.

Then, to compare the answer to each question of the questionnaire between municipalities, we calculated the *d*-value, which means the difference between the mean values of the two groups of municipalities for the same question. Therefore, if $[E(X_{q,b})]$ represents the well-performing group and $[E(X_{q,r})]$ the poorly performing group, then $d = E(X_{q,b}) - E(X_{q,r})$.

Given the increasing values on the Likert scale, it is expected that the agents of the well-performing group assign low values for variables of potentially negative impact to management to their municipality. Thus, if the mean difference between the groups for a given question is zero, nothing can be concluded about the differences between the groups. If the mean difference between the groups for a given question is negative, the agents in the first group attributed a lower value to that variable than the

agents of the poorly performing group, which agrees with the expected. On the other hand, if the difference between the two groups is positive, the value assigned by the first group would be more significant, therefore, different from expected. Thus, the hypotheses were summarised as:

H_0: $d = 0$ (nothing can be concluded)

H_1: $d < 0$ (agreed with the expected perception)

H_2: $d > 0$ (disagreed with expected perception)

3 RESULTS

3.1 PERCEPTION OF ENVIRONMENTAL AGENTS

Overall, 74 municipal agents from 53 municipalities, representing 37.1% of 143 municipalities of Pará, responded to the questionnaires (Table 1). Of these, 41 (56%) agents were from the well-performing group and 33 (44%) from the poorly performing group.

Table 1 | Municipalities of Pará that participated in the study of performance in environmental management.

Municipalities with good performance	*Poor performing municipalities*
Acará, Altamira, Anapu, Augusto Corrêa, Aveiro, Bagre, Baião, Barcarena, Benevides, Bonito, Bragança, Bujaru, Curuá, Faro, Itaituba, Jacareacanga, Maracanã, Marapanim, Novo Progresso, Quatipuru, Rurópolis, Santa Bárbara do Pará, Santarém, Santarém Novo, Senador José Porfírio, Tailândia, Uruará.	Brasil Novo, Breu Branco, Cachoeira do Piriá, Canaã dos Carajás, Capanema, Capitão Poço, Castanhal, Concórdia do Pará, Dom Eliseu, Floresta do Araguaia, Irituia, Jacundá, Marabá, Ourém, Palestina do Pará, Piçarra, Placas, Santa Luzia do Pará, Santa Maria das Barreiras, Santa Maria do Pará, Santana do Araguaia, São Francisco do Pará, Terra Alta, Tucuruí, Vitória do Xingu, Xinguara.

Source: The authors; and Silva, Azevedo-Ramos and Farias (2019) for performing groups

During this research, most agents qualified the management of their municipality as good (n = 31; 41.9%) or fair (n = 27; 36.5%) regardless of the performance rating of the municipality (Table 2). Only 7 agents (21.2%) from the poorly performing group rated their municipality as having poor management, while 15 agents from this group rated as having very good or good management. On the other hand, most agents from the well-performing group (n = 22; 53.7%) classified their municipality as having good management. Still, 16 agents (39%) classified it as just fair (Table 2). Thus, the agents from the poorly performing group had a perception different from that previously calculated for their municipality. The same occurred with the agents of the other group but to a lesser extent.

Table 2 | Qualification of the municipal environmental management by local agents divided into previously classified groups in Pará, Brazil.

Group of the interviewee	*Environmental Management*				
	Very good	*Good*	*Fair*	*Bad*	*Total*
Well-performing municipalities	1 (2.44%)	22 (53.66%)	16 (39.02%)	2 (4.88%)	41 (100%)
Poorly performing municipalities	6 (18.18%)	9 (27.27%)	11 (33.33%)	7 (21.21%)	33 (100%)
Total	7 (9.6%)	31 (41.89%)	27 (36.49%)	9 (12.16%)	74 (100%)

Source: The authors

Overall, the agents indicated institutional and economic issues as the major threats to environmental management (Figure 1). The agents (n = 41) from the well-performing municipalities prioritised threats of economic nature (21.4% incentive to agricultural production; and 19% low GDP) over institutional ones (19% low institutional capacity). In turn, the agents (n = 33) from the poorly performing municipalities chose options predominantly related to institutional issues (27.3% low institutional capacity and 18.2% low access to information on rural properties).

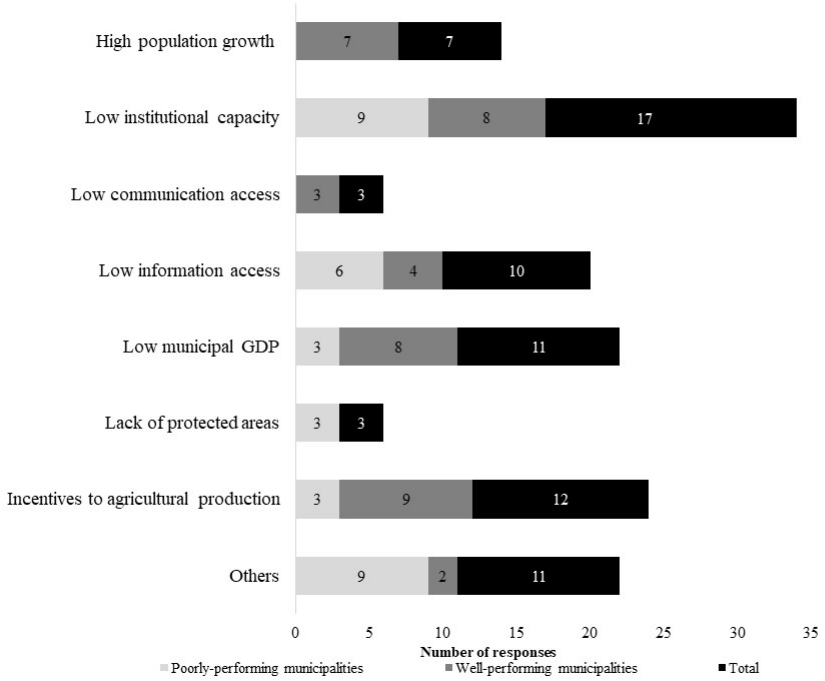

Figure 1 | Threats to municipal environmental management according to local agents based on survey.

Source: The authors.

The descriptive statistics of answers to the questionnaire with the Likert scale can be seen in Table 3. Among the variables of potential positive impact on management, the agents from the well-performing group scored highest on the number of *City Hall officials* and the presence of *protected areas*. On the other hand, among the variables of potentially negative impact, none was classified as high in their municipalities. On the contrary, the highest variables were close to fair in their opinion (*pasture, secondary vegetation and burned areas*).

Table 3 | The responses of the environmental agents by groups of municipalities (mean, SD = standard deviation; and n = number of samples). Response options on the Likert scale: 1 (low) to 4 (very high).

	Well-performing municipalities			*Poorly performing municipalities*		
Negative effect variables	*Mean*	*SD*	*n*	*Mean*	*SD*	*n*
Infant mortality	1.31	0.48	29	1.24	0.72	17
Abandoned pasture	1.34	0.79	29	1.70	0.82	27
Rural credit	1.46	0.54	26	1.90	0.44	20
Rural environmental register	1.83	0.72	40	2.67	0.62	30
Increased deforestation	1.84	0.96	37	1.69	0.90	29
Agricultural area	1.84	0.90	38	1.79	0.90	29

	Well-performing municipalities			Poorly performing municipalities		
Negative effect variables	*Mean*	*SD*	*n*	*Mean*	*SD*	*n*
Deforested area	1.85	0.84	34	2.53	0.91	30
Degraded area	1.92	0.71	38	2.50	0.69	28
Pasture area	2.16	0.76	38	2.59	0.58	29
Secondary vegetation	2.24	1.03	37	2.38	0.95	29
Burned area	2.27	0.73	37	2.13	0.81	30
Partial mean	1.82	0.77	34.8	2.10	0.76	27.1
Positive effect variables	Mean	DP	n	Mean	DP	n
Paid environmental fines	1.24	0.50	34	1.45	0.78	29
Green tax	1.39	0.73	36	1.61	0.79	28
Intensification of livestock	1.67	1.11	39	2.41	0.74	29
Internet access	1.71	0.58	41	1.88	0.64	20
Demographic density	1.74	0.67	34	1.58	0.62	31
Environmental fund	1.78	0.93	36	1.66	0.81	29
Quality of life	1.81	0.65	42	1.84	0.80	31
Telephony access	1.86	0.78	42	2.41	0.71	32
Environmental surveillance	1.93	0.69	41	2.14	0.88	29
City Hall council	2.07	1.22	41	2.19	1.11	31
Population growth	2.27	0.73	37	1.79	0.69	28
Institutional capacity	2.37	0.77	41	2.47	1.01	30
Environmental laws	2.41	0.81	41	2.68	0.91	31
City hall officials	2.50	0.72	32	2.38	0.65	24
Protected areas	2.68	0.75	37	1.54	0.78	28
Partial mean	1.96	0.77	38.3	2.00	0.79	28.7

Source: The authors.

For the agents from the poorly performing group, *environmental laws* and the *institutional capacity* received the highest scores among variables with a potentially positive effect on management (between fair and high). Among the variables of potentially negative impact, the highest scores were for the *rural environmental register, pasture area and deforested/degraded* area (near high). It is worth noting that the Rural Environmental Registry was included in the group of variables with a potentially negative impact given a temporary speculative increase in deforestation after its creation in 2012 (AZEVEDO *et al*., 2017).

Considering aggregated responses for all variables, there was a significant difference (t = -3.30; d.f. =1553; p = 0.001) between the two groups of municipalities (Figure 2a). When analysing only the responses for the variables of potentially negative effect on management, there was a significant difference in perception between the two groups of municipalities (t = -4.43; d.f.= 440; p< 0.001; Figure 2b). Agents from the poorly performing group attributed higher values to these variables than agents from the well-performing group. However, when analysing only the responses for the variables with potentially positive effects on management, there were no significant differences between the responses of the two groups of municipalities (t = -0.7; d.f. = 930; p = 0.484; Figure 2c), indicating that the agents similarly scored these variables in the two groups of municipalities.

Thus, variables of potentially negative impact on management were vital to differentiate agents' perceptions regarding the management of their municipality. Therefore, these variables will be analysed in more detail next.

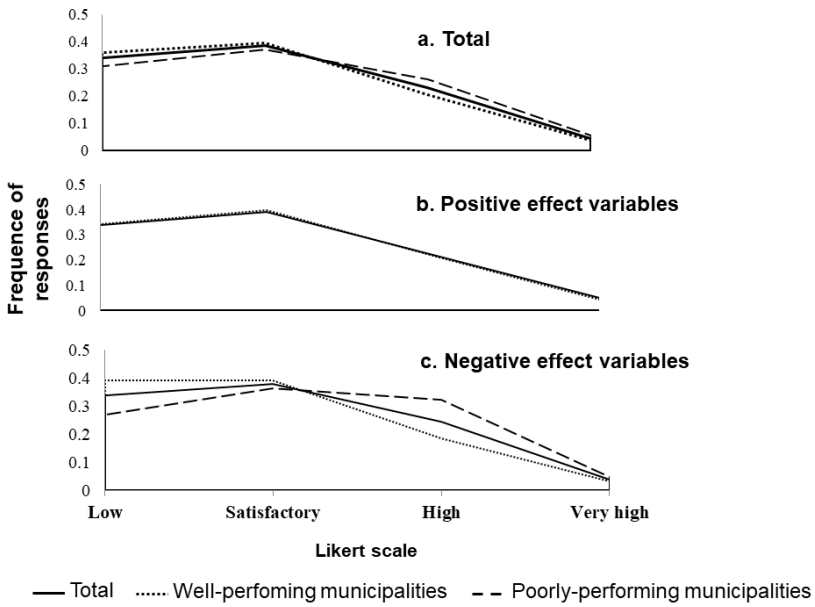

Figure 2 | Distributions of the agents' answers by municipal performance groups: a) all variables; b) potentially positive impact variables; and c) potentially damaging impact variables.

Source: The authors.

3.1.1 KEY VARIABLES IN THE PERCEPTION OF MUNICIPAL ENVIRONMENTAL MANAGEMENT

As the variables of potentially negative effect to environmental management presented significant differences between the responses of the two groups of municipalities, only this group of variables was used in the hypothesis test.

There were three variables *(abandoned pasture, infant mortality and rural credit)* in which the perception of agents from the well-performing group coincided with what is expected for their municipalities (H_1), that is, below average values (Table 4a). However, for seven variables, there were no differences in the total mean of the questionnaires. Therefore nothing could be concluded.

There were five variables *(degraded area, secondary vegetation; deforested area; pasture area and rural environment register)* in which the perception of agents from the poorly performing group were within the expected for their municipalities (H_1), that is, above average values, challenging the environmental management in these municipalities.

Only one variable in each group was different from expected (H_2): secondary vegetation higher than average in the well-performing group and infant mortality lower than average in the poorly performing group (Table 4a).

In sum, of the 11 variables associated with land-use assessed, 27.3% (n = 3) were perceived as expected for well-performing municipalities (i.e., below average), and 45.5% (n = 5) for the poorly performing municipalities (i.e., above average). One variable for each group was perceived differently than expected (secondary vegetation for the former and infant mortality for the latter group). About 64% (n = 7) and 45% (n = 5) of the variables had inconclusive results for well-performing and poorly performing municipalities, respectively.

Then, we calculated the *d*-value, which means the difference between the mean values of the two groups of municipalities for the same question (Table 4b): H_0: $d = 0$ (nothing can be concluded) H_1: $d < 0$ (agreed with the expected perception); H_2: $d > 0$ (disagreed with expected perception). Five variables *(rural environmental register, degraded area, deforested area, rural credit and abandoned pasture)* agreed with the expected (Table 4b). That means the agents from the well-performing group assigned lower values to these variables in their municipalities than the other group agents. In addition, this second hypothesis test helped show the trend for some variables where nothing could be concluded (H_0) in the first test (Table 4a), such as the *degraded area, deforested area, and rural environmental register* the well-performing group.

Table 4 | Hypothesis tests for the perception of agents considering only variables with potentially negative effects on management. See text for hypothesis in "a" and "b".

a - within performance group

	Well-performing municipalities			*Poorly performing municipalities*		
Variable	*t*	*p*	*Hypothesis*	*t*	*p*	*Hypothesis*
Degraded area	-0.525	0.602	H0	3.952	0.001	H1
Deforested area	-0.784	0.438	H0	3.359	0.002	H1
Increased deforestation	-1.204	0.236	H0	-1.951	0.061	H0
Burned area	1.945	0.060	H0	0.923	0.364	H0
Crop area	-1.091	0.283	H0	-1.241	0.225	H0
Pasture area	1.057	0.297	H0	3.443	0.002	H1
Abandoned pasture	-7.091	0.000	H1	-1.995	0.057	H0
Secondary vegetation	2.200	0.034	H2	3.443	0.002	H1
Infant mortality	-6.678	0.000	H1	-7.039	0.000	H2
Rural envir. register	-1.270	0.212	H0	5.275	0.000	H1
Rural credit	-4.559	0.000	H1	-0.571	0.575	H0

b - difference (d-value) between the mean values of the two groups of municipalities

Variable	*Difference (d)*	*t*	*V*	*P-value*	*Hypothesis**
Rural envir. register	-0.84	-4.70	65.39	0.00	H1
Degraded area	-0.58	-3.31	59.17	0.00	H1
Deforested area	-0.68	-2.93	61.74	0.00	H1
Rural credit	-0.44	-2.39	38.86	0.02	H1
Abandoned pasture	-0.36	-2.16	44.90	0.04	H1
Pasture area	-0.43	-1.77	62.68	0.08	H0
Secondary vegetation	-0.14	-0.82	63.40	0.41	H0
Crop area	0.05	0.25	59.26	0.81	H0
Infant mortality	0.08	0.51	39.47	0.61	H0
Burned area	0.14	0.62	62.24	0.54	H0
Increased deforestation	0.15	0.77	57.04	0.44	H0

Source: The authors.

4 DISCUSSION

Environmental decentralisation policies were implemented in the municipalities of Pará to improve the quality of local environmental management (ASSUNÇÃO; ROCHA, 2014; BORGES DE LIMA; BUSZYNSKI, 2011; NEPSTAD *et al*., 2014; VIANA *et al*., 2016). Economic incentives and a better legal definition of municipal environmental decentralisation were responsible for a greater adherence of municipalities to the decentralised management regime, which increased from 10 municipalities in 2009 to 123 in 2019 (SILVA; AZEVEDO-RAMOS, 2016). In turn, municipalities had to evolve to a more sustainable local development model and a better management performance. That demanded greater responsibility and effective participation of local agents in controlling deforestation and strengthening the municipal environmental systems of Pará (NEVES; WHATELY, 2016; VIANA *et al*., 2016). However, the monitoring of municipal environmental management did not occur at the same speed as the adherence to the decentralised regime.

According to Fowler (2018), State or intergovernmental management approaches shape how local governments interact and how much influence local managerial efforts have on policy outcomes, leading to different local managerial perceptions and agency effectiveness. With the evolution of the political-administrative decentralisation, local governments tend to gain maturity and authority to manage programs to meet local needs and national standards, interacting voluntarily with other administrative levels and managing shared goals (AGRANOFF; MCGUIRE, 2001; ALLIK; REALO, 2004). As local environmental impacts may have transboundary effects, affecting the state's socioeconomics, a joint effort from local governments is necessary to achieve a greater good. In practice, at the beginning of a decentralisation process, however, local environmental public agents should have a clear state-led orientation towards their goals to narrow the spectrum of their judgments about priorities that otherwise may result in different inter-municipal performances. This is rarely the case in Amazon municipalities, leading to a mix of different outcomes regarding environmental management. In this sense, the balance that allows a decentralised regime not to depart from the common good, in this case, effective environmental management in the municipalities, has yet to be experienced in the Amazon. Likewise, the lack of comparison instruments to assess the evolution of municipalities and plan corrective measures undermines the quality of local environmental management (MOLDAN; JANOUŠKOVÁ; HÁK, 2012; TANGUAY *et al*., 2010). Continuous monitoring would also enable a better perception of agents in the short, medium and long term, allowing learning throughout the process.

In this study, public agents qualified the municipal environmental management (usually, good or fair) differently from that expected based on the group to which the agent belongs (according to the previous study by Silva, Azevedo-Ramos and Farias (2019). The agents from well-performing municipalities tended to underestimate their management slightly. In turn, the agents from the poorly-performing group saw their municipalities more optimistically than reality. It is noteworthy that this group of municipalities was also the one that received the most incentives to improve the quality of its management (SILVA; AZEVEDO-RAMOS, 2016), such as local agents training and equipment acquisition (e.g. vehicles, motorcycles, computers) financed by the Amazon Fund and the State Environmental Fund. The injection of financial and institutional incentives without verified compliance may also induce a false perception by local agents that the municipality improved its management.

Furthermore, the lack of feedback from monitoring systems for agents may cloud their judgment regarding the quality of management in their municipality (CRIOLLO; MALHEIROS; ALFARO, 2019). Moreover, the diversity of management objectives has proven to complicate decision-making processes when accounting for stakeholders' views (HAMILTON; SALERNO, 2020). Similarly, socioeconomic trade-offs of land-use change may bias the perception of environmental impacts (CÓRDOBA *et al*., 2019).

Agents perceived the institutional and economic deficiencies of the municipalities as threats to environmental management, which may hinder the transition to the decentralised regime in Pará (SILVA; AZEVEDO-RAMOS, 2016). However, the agents of the two groups of municipalities prioritised

different threats: institutional capacities (conjunctural causes) for the poorly performing group; and economic issues (structural causes) for the well-performing group. The lack of institutional capacity in the Amazon municipalities is undeniable but transversal to all municipalities and, therefore, not enough to explain differences in performance. Structural causes may demand a better understanding of agents between proximal and ultimate causes. However, the agents of the poorly performing group seemed to miss (or underestimate) the effect of economic factors (such as incentives to agriculture and low GDP of municipalities) on environmental management compared to good performers. Perception results from a different set of factors, such as political, demographic, socioeconomic, biophysical, among others (BENNETT, 2016; GUTHIGA, 2008). In this case, it seems that a broader perception of the local conjuncture may lead to better management.

Overall, the variables with potentially positive effects on management used in this study denote conditions for structured management (e.g., infrastructure, credit, employees, institutional capacity). Agents of the two groups showed similar perceptions about these variables, assigning low values to them. That means that the agents from all municipalities were working under suboptimal conditions according to their perception. On the other hand, agents' perception about the variables of potentially negative impact to management was vital to differentiate the groups. The magnitude of these variables mainly described the output of management actions (e.g., deforestation, fire outbreaks, degraded area). Therefore, what may be influencing the management performance is the predominant type of land-use practices in each municipality. These findings may contribute to improving local environmental management by enhancing the control or mitigation of land-use changes. Furthermore, this measure involves a better understanding by agents about the impacts of unsustainable practices on environmental management, which may be clouded when these are the most common practice in a given municipality.

Of the 11 variables associated with land-use changes, 27.3% were perceived as expected for well-performing municipalities (i.e., changes below average), and 45.5% for the poorly performing municipalities (i.e., changes above average). Those results might suggest that conspicuous changes are easier to identify by agents, while discrete ones may go unnoticed. Therefore, the joint monitoring by empirical data may contribute to reinforcing warnings before it is harder to reverse the problem. Overall, the agents attributed values consistent with what was expected for their group of municipalities for five variables: *rural environmental register, degraded area, deforested area, rural credit and abandoned pasture*. In other words, the agents were able to assess their municipalities concerning these variables satisfactorily. The similarity between an agent's perception and the empirical analysis, in this case, suggests that the monitoring of these specific variables may result in greater effectiveness in choosing strategies for improving environmental management. For instance, in municipalities with poor environmental performance, monitoring actions focused on the five variables may improve the municipality's performance.

5 CONCLUSION

In conclusion, the agents' perception about the overall quality of the management of their municipality was different from that expected for their performance group. Land-use practices were relevant to distinguish the two groups of municipalities. Taken together, the impact of economic activities in each municipality may challenge the local environmental management.

The results highlighted the importance of incorporating perception as evidence for improving conservation and governance policies. The relevance of incorporating perception was also shown in other studies with different thematic (BICKLEY *et al*., 2020; CARMENTA *et al*., 2017; OKUMAH, YEBOAH, 2020). Although the agents' opinions do not necessarily reflect the institutional opinion, their perception about municipal environmental management may be an ally for a quick assessment of the quality of management. On the other hand, a misperception of reality may undermine better environmental

management. In this way, mixed methodologies, which allow monitoring the management with the active participation of environmental agents and empirical data, may be more effective in assessing the quality of management.

This study demonstrated that the agents' perception of the municipal environmental management might not fully agree with the results of municipal performance previously calculated from secondary data (SILVA; AZEVEDO-RAMOS; FARIAS 2019). Better incorporation of diversified monitoring and information feedback to these agents may improve local environmental governance. To reduce costs, public environmental agencies could focus first on the variables that the agents attributed values consistent with what was expected for their group of municipalities: *rural environmental register (CAR), degraded area, deforested area, rural credit and abandoned pasture*.

These findings may be helpful in decision-making processes in environmental management on a large scale. It also highlights the importance of including human factors before implementing a policy, mainly through capacity building/training of public agents. The empowered local social capital may be an ally in identifying solutions to problems, significantly increasing the effectiveness of environmental policies.

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Applying a participatory methodology to evaluate ecosystem services in the Pampa biome: lessons learned from the Tessa methodology in Uruguay

Aplicación de metodología participativa para evaluación de servicios ecosistémicos en el bioma Pampa: lecciones aprendidas del método Tessa en Uruguay

Daniela Schossler [1]

Carlos Nabinger [2]

Claudio Ribeiro [3]

Pablo Boggiano [4]

Monica Cadenazzi [5]

Diana L. Restrepo-Osorio [6]

[1] *Master's Degree in Soil and Water Management and Conservation, PhD candidate, Department of Animal Production and Pastures, Faculty of Agronomy, University of the Republic of Uruguay, Paysandú, Uruguay*
E-mail: tessapilotobrasil@gmail.com

[2] *PhD in Animal Science, Professor, Department of Forage Plants and Agrometeorology, Faculty of Agronomy, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil*
E-mail: nabinger@ufrgs.br

[3] *PhD in Rural Development, Professor, Universidade Federal do Pampa, Bagé, Brazil*
E-mail: claudioribeiro@unipampa.edu.br

[4] *PhD in Animal Science, Professor, Department of Pastures, Faculty of Agronomy, University of the Republic of Uruguay, Paysandú, Uruguay*
E-mail: prboggia@fagro.edu.uy

[5] *PhD in Animal Science, Professor, Department of Pastures, Faculty of Agronomy, University of the Republic of Uruguay, Paysandú, Uruguay*
E-mail: monicade@fagro.edu.uy

[6] *PhD in Geography, The University of Kansas; United States Geological Survey (current affiliation), Kansas Water Center (USGS KWSC), Lawrence, Kansas, USA*
E-mail: restrepita.diana@gmail.com

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ABSTRACT

Identifying and measuring ecosystem services involving local stakeholders has been characterised as a novel approach in the literature. This article describes the methodology used in the participatory workshops, the lessons learned, and the specific results of applying the Tessa method. The methodology was piloted with 56 researchers and technicians, more than 22 institutions, and 54 livestock producers involved with the grassland conservation initiative, Alianza del Pastizal. Identified change agents with the most significant impact include the absence of a rural workforce, the lack of family succession, and weeding and overgrazing of grasslands. The primary ecosystem services identified included the production of fodder, meat/wool, wildlife forage, way of life/culture, and medicinal plants. The methodology presented here is replicable, capable of expansion to more groups, contributes to a better understanding, by the producers, of their problems and points to the need for the development of public incentive policies.

Keywords: Extensive livestock farming. Ways of life. Sociocultural perceptions. Native grasslands. Incentive-based policies. Conservation.

RESUMEN

Identificar y medir servicios ecosistémicos involucrando actores locales tiene carácter novedoso en la literatura. El artículo describe el método utilizado en los talleres participativos, las lecciones aprendidas y los resultados específicos de la aplicación del método Tessa. La metodología fue aplicada de forma piloto con 56 investigadores y técnicos, más de 22 instituciones y 54 productores ganaderos involucrados con la iniciativa de conservación de campo natural, Alianza del Pastizal. Los agentes de cambio con mayor impacto, apuntados por los participantes, fueron la ausencia de trabajadores rurales, la falta de sucesión familiar, el enmalezamiento y sobrepastoreo de los campos. Los principales servicios ecosistémicos, producción de forraje, carne/lana, alimentación para fauna silvestre, modo de vida/cultura y plantas medicinales. La metodología es replicable, capaz de ser expandida a más grupos aportando al mejor conocimiento por parte de los productores de sus problemas y apuntando para la necesidad de desarrollo de políticas públicas de incentivo.

Palabras clave: Ganadería extensiva. Modo de vida. Percepción sociocultural. Campo natural. Políticas de incentivo. Conservación.

1 INTRODUCTION

The concept adopted worldwide for ecosystem services (ES) is anthropogenic: "benefits provided by ecosystems to humans" (MEA, 2005, p. 23). However, in developing public policies, local stakeholders, the primary beneficiaries and maintainers of the ecosystem, do not always have a central and omnipresent role in discussing important issues. This approach emphasises the role of culture in defining all links between people and nature (DÍAZ *et al*., 2018).

South American natural temperate and subtropical fields, which are spatially heterogeneous (BERRETTA *et al*., 2000), constitute the primary forage base of Uruguay. It is the most important nutritional resource for cattle and sheep breeding and includes one of the most critical assets in terms of biodiversity (MGAP, 2012). A diversity of species coexists in grazing contexts and depends on it to remain productive and existing. This combination provides a range of valuable ecosystem services that affect human well-being (VIGLIZZO; FRANK, 2006; WEYLAND *et al*., 2017).

Identifying ecosystem services with participatory methodologies involving users and beneficiaries of natural fields is novel in the literature. According to the analysis made by Castillo (2019, p. 120), publications on the SE thematic and social dimensions, specifically "giving voices to different actors", are scarce in South America. Most research (61%) lacks the inclusion of local actors; of that, only 13% address the agents of change (causes/factors of alteration of the natural ecosystem).

The Toolkit for Ecosystem Service Site-Based Assessment (Tessa) provides accessible guidance for low-cost methods to assess the benefits people receive from nature at particular sites to generate information that can be used to influence decision-making (PEH *et al*., 2017). However, it does not have defined protocols for rural ecosystems or proposed a method for identifying and involving stakeholders.

The Tessa methodology was first applied in the countryside ecosystem in Brazil in the year 2016 by Schossler (2016), then Argentina (SCHOSSLER *et al*., 2016a), Paraguay (SCHOSSLER *et al*., 2016b) and then Uruguay between the years 2016 and 2020 funded by BirdLife International. The lessons learned in this article result from applying the method in participatory workshops in the four countries with 56 researchers involved with the SE and social dimensions thematic, more than 22 institutions and 54 participating producers associated with the Alianza del Pastizal.

The Alianza del Pastizal (AP), an initiative to promote sustainable livestock farming, works to preserve natural pastures, also called temperate grasslands, among livestock farming communities in Uruguay, Paraguay, Argentina, and Brazil. One of the projects they promote is the certification of estates with at least 50% of the area with natural grasslands in a good state of conservation (PARERA *et al*., 2014).

The objectives of the article are a) to describe the method used in the participatory workshops for the assessment of ecosystem services and agents of change as a basis for the development of the Tessa methodology; b) to disseminate the lessons learned in the pilot workshops in the four countries; c) to report the results of the case study in Uruguay.

2 METHODOLOGY

2.1 IDENTIFICATION OF STAKEHOLDERS

In February 2016, a pilot workshop was held with professionals and technicians working with natural grasslands to inform and evaluate the Tessa methodology in Uruguay. In addition, the tools and characteristics that were necessary for the selection of the study sites were also discussed.

The study “site” was defined as the management unit or potential study unit. The possible area can be protected, identified as necessary from a biodiversity point of view. The site should be an operational or potential management unit, such as a protected area or an area important for birds and biodiversity. It generally ranges in size from 100 to 100,000 ha, with boundaries established by stakeholders.

For the site selection, we used the historical environmental certifications based on the Grassland Conservation Index (ICP), which were developed by the Alianza del Pastizal (PARERA *et al*., 2014). Data from 215 certified farms in Uruguay were evaluated. Properties with the most representative ICP ranges in the country were chosen. These were located close to each other, in a landscape of biological importance, with similarities of fields, land use, and producers as ranchers in natural grasslands. Based on these criteria, Colonia Juan Gutiérrez was chosen, which had 30 certified properties organized in the Sociedad de Fomento de la Colonia Juan Gutiérrez (SFCJG).

2.2 URUGUAY CASE STUDY: CHOOSING THE ACTORS

Colonia Juan Gutiérrez (CJG) is located between the latitudes of 320 12,554’ and 320 7,530’ South and the longitudes of 570 15,198’ and 570 26,308’ West. It is in the department of Paysandú and the city of Guichón. CJG has an area of 8,300 hectares and approximately 30 properties, most of which practice cattle ranching, with an average of 300 hectares per property. The properties’ fields belong to the National Institute of Colonization (INC), and the producers are tenants and must follow the INC criteria.

The Colonia is located at the confluence of the Queguay Grande and Queguay Chico rivers, where the Montes del Queguay Managed Resource Protected Area is located (Figure 1). The boundaries of the protected area are defined by the limit of the potential flooding surface. The area was valued for entry into the National System of Protected Areas (Snap) for its environmental diversity highlighting its uniqueness and low degree of intervention. This area also has elements of interest for protecting the ecosystem and priority species for conservation (MEDINA *et al*., 2019). The Snap protects producers with the presence of a park ranger.

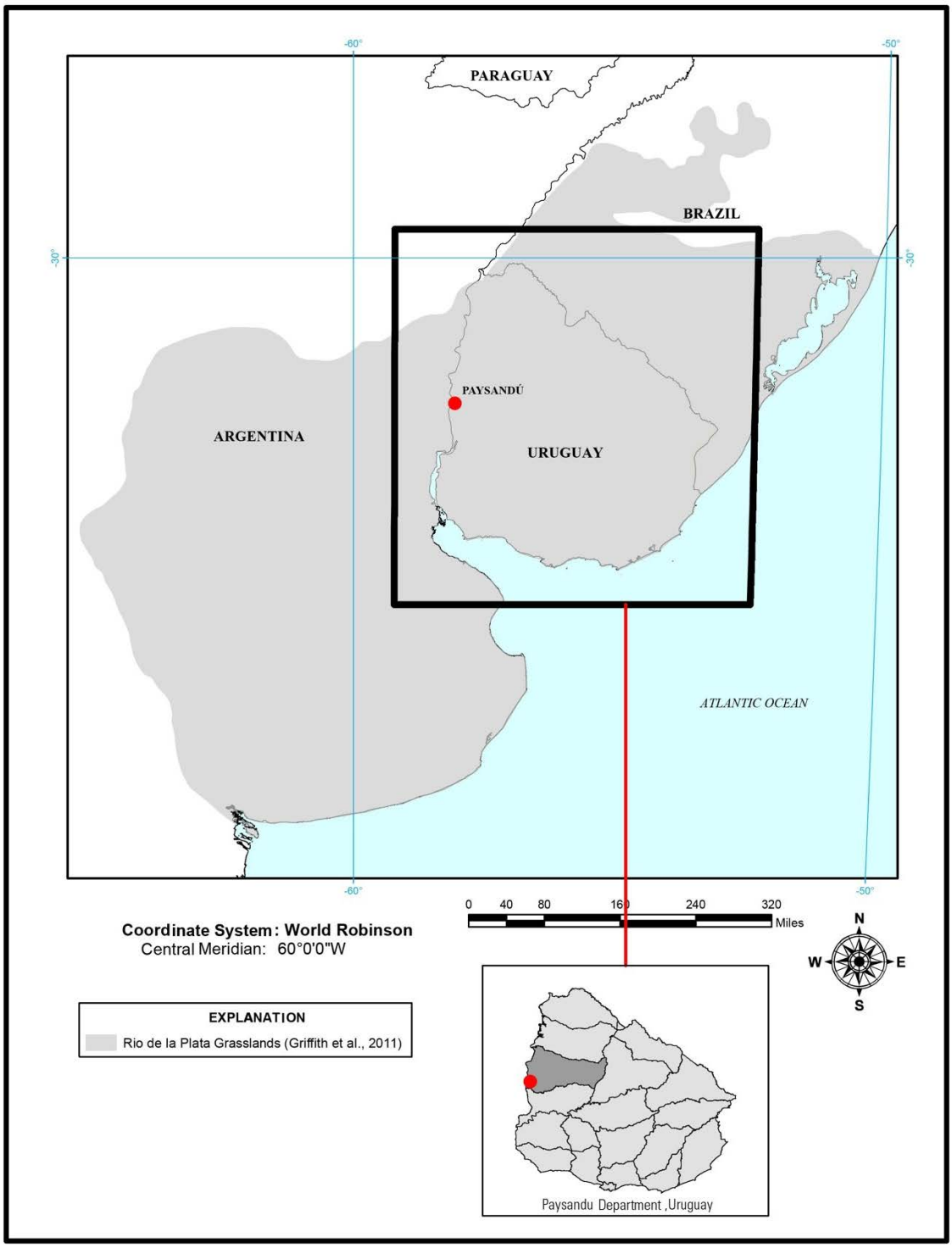

Figure 1 – Location of the study area, Colonia Juan Gutiérrez, Guichón, Department of Paysandú, Uruguay. In gray the location of the Río de la Plata grasslands.

Source: Own elaboration according to Griffith et al., 2011.

The SFCJG, founded in 1975, is an association of producers, where each participant maintains legal independence and managerial autonomy and takes part voluntarily in a joint effort (BÁEZ, 2005).

The Instituto Plan Agropecuario supports, articulates and develops projects with the CJG and other institutions (MACHÍN, 2019) such as the Instituto Nacional de Investigación (Inia), the Ministerio de Ganadería Agricultura y Pesca (Mgap) and, the Comisión Nacional de Fomento Rural, all of this supported by the SFCJG legal entity.

The Alianza del Pastizal has historically collaborated with the producers of Colonia. In 2014, the Inter-American Development Bank (IDB) financed a project where 30 CJG farms were certified with the ICP. In addition to that initiative, between 2013 and 2017, Inia and New Zealand developed the "Uruguay Family Farm Improvement Project" titled "Improving the Sustainability of Family Farming in Uruguay" to evaluate the ICP at the start and the end of the project.

2.3 TESSA GUIDE STEPS

This article discusses the execution of the "Preliminary Scoping Assessment", which is step 2 of the Tessa method (Figure 2). This step addresses the questions: a) What will change in the ecosystem services because of management decisions, and b) What impact will this have on different groups of producers according to the benefits the chosen site confers?

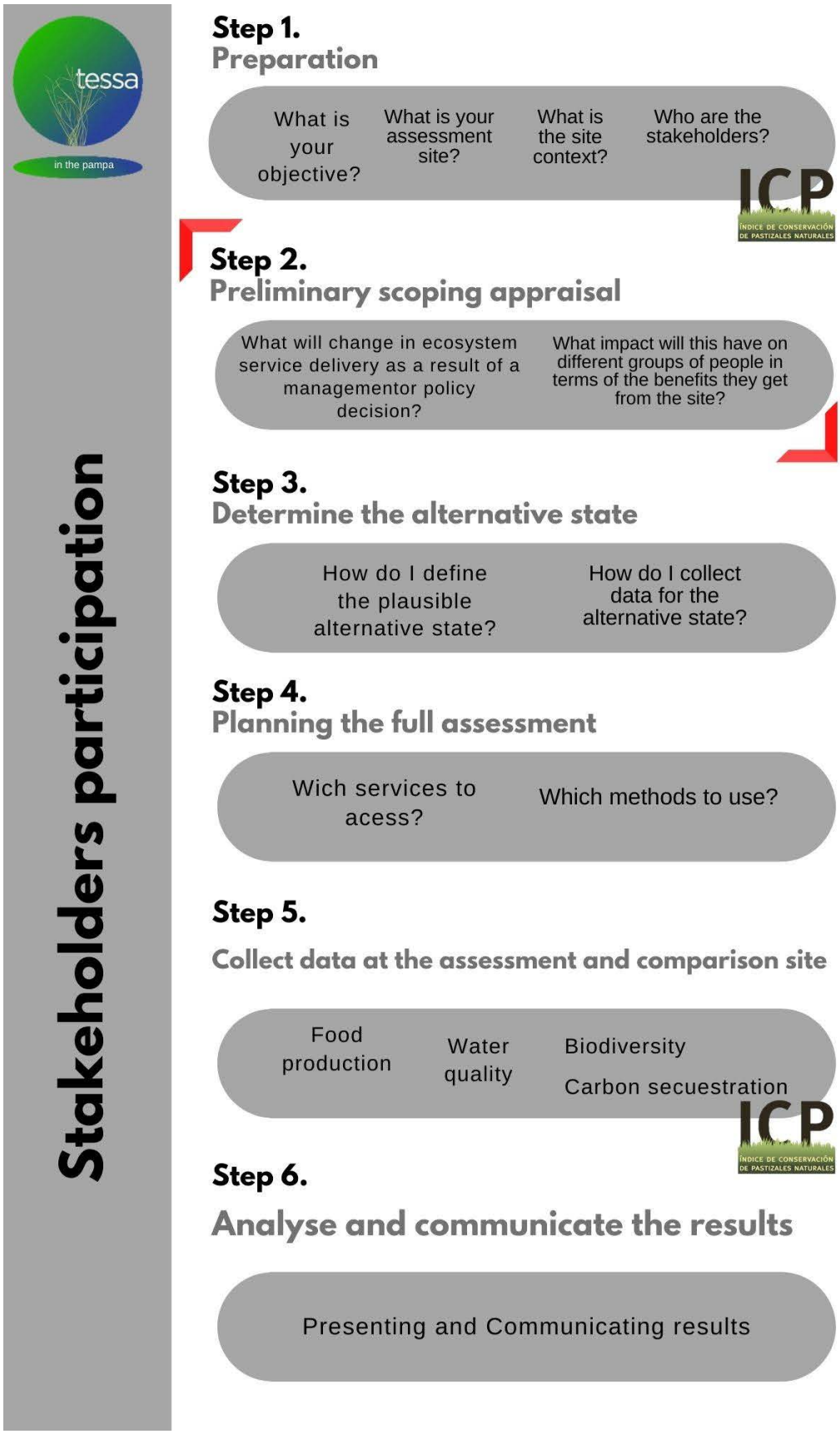

Figure 2 | Steps of the Tessa method in the pampas and the use of the Grassland Conservation Index (Step 1 and 5).

Source: Created by author, adapted from the guide of PEHL et al. (2017).

The expected results identify the ES that will be evaluated in the field and make it possible to answer the questions for the next methodological steps (Step 5).

2.4 PARTICIPATORY WORKSHOPS METHODS

The method adopted for the workshops had three main steps: first, the presentation and sensitisation on the central theme of "ecosystem services"; the second step is the group exercises described below, and the third step is the discussion and generalisation of the relevant information arising from the workshop.

The information generated was compiled and evaluated, and easy-to-interpret graphs where stakeholders can quickly identify their perceptions were generated. Hypothetical changes in ecosystem services and their distribution under an alternative state (if the targeted threats are established, e.g., change due to agriculture) were compared. The results were then interpreted about possible management strategies.

Step 1: Presentation and raising awareness

A brief explanation of approximately 30 minutes was given in empathetic and straightforward language on the concept, classification, and examples of ecosystem services in natural grasslands.

Step 2: Group exercises: descriptions and tables used to identify agents of change and ecosystem services.

Producers are divided into small groups of up to 5, and each group completes the basic Tessa information table (completing parts 1 and 2 described below). Worksheets are provided with an explanation of the steps to follow with tables to fill out (Table 1). Additionally, a map of a representative property of the study area (in which the participating stakeholders are included) is distributed. This map contains the total area and area according to soil type, paddocks, and current use.

The first step is to identify the area occupied by each vegetation cover/use since many ecosystem services are provided at the habitat level and are directly associated with the type of vegetation cover. Then, a classification of the main habitats is completed using the information on the type and percentage of the system occupied.

Identification of threats and agents of change

In addition to identifying threats and agents of change, the impact of management policies, possible actions for change on some producers and institutions, and management policies and positive actions on some individuals and institutions were estimated.

Identification of agents of change (threats)				
Threats of the site (pressures)	Time (next 10 years) More than 4 years 2. Within 4 years 3. Now	Scope (proportion of the site that is affected) 1. Small area 2. Some of the area 3. Most of the area	Severity (e.g., degree of of habitat degradation habitat, size of of effect) 1. Low Moderate 3. High	Impact (Time + Scope + Severity)

Identification of ecosystem services (benefits)				
Benefits	Current Status (Score 0-5) 5 = very important	Five prioritized services in current status	Alternative status (Score 0-5) 5 = very important	Five services prioritized in the alternative state

Characterization of the main ecosystem services				
Benefits (5) prioritized from table 2	Who benefits? Local/District/National/ Global	How has availability changed in the last five years? Large increase 1. little increase 0. no change -1. Little decrease -2. Large decrease	How will this benefit change in the alternative state? Large increase 1. little increase 0. no change -1. Little decrease -2. Large decrease	What are the main agents of change (cause/factor) of this change?

Table 1| Tables used in the workshops to identify agents of change (threats), current and alternative state ecosystem services and characterise likely future changes.

Source: Created by author

The first step is completed by estimating possible short- and medium-term decision outcomes, meaning10 years from now, and caused by current trends at the site without any intervention to mitigate those trends. The estimation of outcomes should consider a) the current and potential agents of change for the site in short to medium term (now or in the next 10 years); b) how immediate are these changes; c) how likely are these changes to occur?; d) what is the extent of these changes to the habitats and biodiversity of the site in terms of area and what will be the magnitude of the change (extent); e) how will these agents of change affect the habitats and biodiversity of the site in terms of the magnitude of effect? (e.g., degree of habitat degradation, size of effect). This last scenario is referred to as the "alternative state".

In the alternative state or change scenario, it is necessary to emphasise the productive, social, ecological, and economic benefits of altering the current state. Evaluating a particular ecosystem service is a practical step to know the benefits it provides to people. Still, it is essential to understand the social, ecological, and economic consequences of changing its current (conserved) state compared to a plausible alternative. An alternative form may be the replacement of the natural grassland by agriculture or restoring the present natural grassland, using various management plans and improvements by adding agricultural inputs. Impact assessments resulting from changes in land use may be more helpful to decision-makers than single state values. Comparative estimations can directly impact biodiversity and ecosystem services, and they can also provide information on who is affected (PEH *et al*., 2013).

Ecosystem services identification

A sheet is provided with a brief explanation of what ES are, their classifications and beneficiaries. Participants start the process by identifying all the benefits provided by natural grasslands in the study region. It is necessary to define and identify the ecosystem services provided by the focus areas to evaluate the range of ecosystem services provided by the sites at all scales. This exercise also allows for the potential contributions of the identified ES at the national and global levels. Table 2 was used for this purpose, where, in the first column, all the benefits are rated from 0-5. 0 = not relevant, 1 = of little importance, 5 = very important. Then, from the highest-scoring benefits in the list, five priority benefits are agreed upon for the site in its current state. The second step is to do the same for the alternative state (if the threats noted above influenced the site) by identifying the benefits provided in the alternative state and their importance, measured on the same scale of 1 to 5. As before, five priority benefits are identified for the alternative state.

Step 3: Plenary discussion to select the most critical ecosystem services.

Characterisation of the primary ecosystem services, their beneficiaries, likely changes, and agents of change.

Using the group discussion methodology, the primary services that emerged from the group work were determined. Special attention was paid to the ideas of non-repetition and complementation of services: which were more important? which were repeated or complementary? The questions of this step were explained, and the answers were completed during the plenary.

It is essential to ensure that in the quantification of ES, there is no double counting. This could occur if the processes and services and the final products are all considered additive components. For example, the value of pollination and crop pest regulation is beneficial processes that manifest through increased food production (a benefit). Therefore, if the value of food production itself is accounted for, crop pollination and pest regulation should not be valued aggregated independently. This additive criterion makes it possible to generate a model free of duplicates and considering that only additive criteria are entered (BALMFORD *et al*., 2011).

At this stage, it is essential to finalise the collected information and generate group discussions to arrive at the crucial benefits and threats and obtain trends and possible future changes.

The objective of this step is to be able to explain a model with the best possible cost/benefit ratio.

2.5 PARTICIPATORY WORKSHOPS

Pilot workshop with researchers and technicians

The workshop series involved 13 different institutions and was facilitated by 18 instructors, researchers, and disseminators in natural grasslands. As a result, the objectives of the Tessa method were achieved, allowing for the subsequent definition of research foci and information dissemination in the study area. Furthermore, with a duration of 4 hours, the objectives of methodological adequacy for the following work with producers of the research focus were met.

Workshop with local livestock producers

This workshop was held with 12 traditional livestock producers from Colonia Juan Gutiérrez, instructors from the Faculty of Agronomy of the University of the Republic of Uruguay, Snap representatives, the administrator and director of the protected area, and the president of the SFCJG. The objective of this second workshop was to learn about the perception of the users and keepers of the selected study site.

3 RESULTS AND DISCUSSION

3.1 MAIN THREATS TO NATURAL GRASSLAND CONSERVATION, TRENDS IN DELIVERY AND LIKELY CHANGES

The perception of ranchers and researchers was shown to be strongly influenced by their experiences with nature, sense of place, and its benefits (CORTÉS-CAPANO, 2020; FAGERHOLM et al., 2020; GOLDSTEIN et al., 2012; RAYMOND *et al.*, 2016; TALLIS; POLASKY, 2009). By recognising the interdependencies between livestock production and ecological systems, the agents of change identified (Figure 3) in this work are linked to the landscape chosen for the study. These results align with similar participatory studies (CORTÉS-CAPANO, 2020; FORMOSO *et al.*, 2020) done in Uruguay, which allows for the extrapolation of the information to other territories.

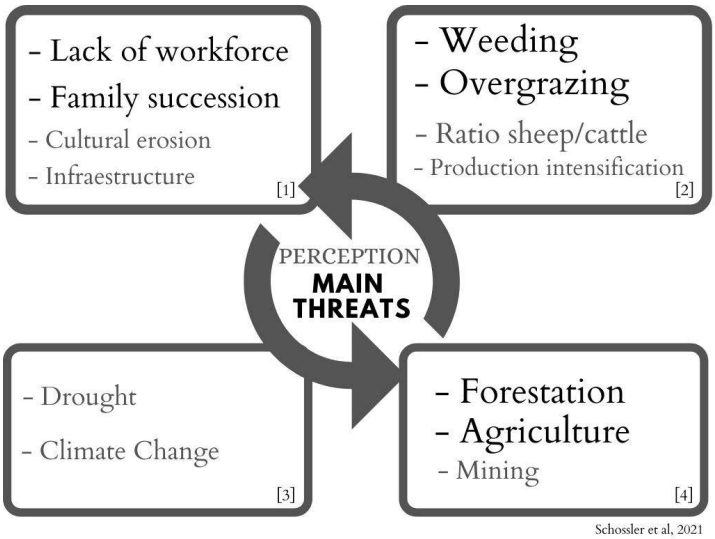

Figure 3 | Perception of the actors involved in the workshops regarding the main threats to the conservation of Uruguay's natural fields and grouped by similarity, where the agents of change with the highest degree of importance are highlighted.

Source: Created by author

The first group [1] is characterised by social issues, where the absence of a rural workforce and the lack of family succession have the most significant impact on the rural population. Producers cite farm size (land division by inheritance), land tenure, and the ageing of the rural population as primary factors for these threats.

Landscape-supported well-being is related to multiple, or lack thereof, interconnected elements that can inform collective visions of well-being in the future (FAGERHOLM *et al*., 2020). The participant groups highlight their concern with cultural erosion (characterised by the loss of occupations), depopulation in the countryside, and the devaluation of one's own culture. Although these results predate the pandemic, likely, the way of life of these cattle ranching communities did not change. Therefore, these ranching families could have served as psychological and environmental refugees, given that Uruguay has a high rural population, which according to the world report on happiness the well-being per person, as well as the average well-being and life expectancy have increased in 2021 compared to the years 2006-2008 (HELLIWELL, 2021).

Changes in the provision of ES can have very different impacts on individuals within a community because access to and control of resources, and alternatives, is determined by factors like land ownership, gender, culture, ethnicity, and social status (DAW *et al*., 2011). In addition, structural problems appear

to have a high impact on conservation, although these are associated with a lack of incentives to the sector. What characterises this is the lack of electricity, connectivity, and road conditions, also cited as threats by Formoso *et al*. (2020, p. 59).

Biodiversity conservation objectives in this cultural landscape cannot be pursued independently of social development objectives (CORTÉS-CAPANO, 2020). Factors affecting production such as weeding and overgrazing [2] are essential to stakeholders, although these are typical responses to management challenges and historical grassland use problems. At the national level, the GEO Report on State and Perspectives of the Environment in Uruguay indicated in 2009 that 30% of the country's territory suffered some degree of erosion where crops like soybean, rice, and corn are responsible for 87% of the eroded areas, and overgrazing for 12% (PÉREZ, 2020).

At the landscape scale, the excessive presence of some undesirable plant species is of concern to producers and technicians. The following species were cited, in order of importance for the weeding/weediness of the field and consequent drop in livestock productivity: Bacharis coridifolia (myo-mio), Eryngium horridum (cardilla), Eupatorium buniifolium (chirca), Baccharis trimera (carqueja) and Heimia salicifolia (quiebra arados). Cited as weeds, they are native fields and cannot be confused with invasive exotic species (CEEI, 2014); their threat is not characterised by presence but by frequency, therefore, the number of species per square meter.

On a larger scale, land-use change has a high impact due to forestation (RESTREPO-OSORIO, 2020) and intensive agriculture [3]. Mining was another activity that emerged; however, according to the actors involved, it is not so worrying. Nevertheless, the identification of drivers (direct and indirect) that affect ES (DÍAZ *et al*., 2015) is urgent given that the grasslands of the Río de la Plata are some of the fastest agricultural expansions not only in Latin America but in the world (BAEZA; PARUELO, 2020) This factor makes it one of the most modified biomes around the globe (BALDI; PARUELO, 2008; HANNAH, 1995; PARUELO, 2007).

External factors, no less important, such as drought and climate change [4], are perceived as threats and join the possibility of an increase in extreme climatic events with the forecast of a 1.5-degree increase in temperature (IPCC, 2021). This is predicted to occur ten years earlier than expected, which is believed to cause a greater frequency and/or intensity of some meteorological and climatic phenomena (IPCC, 2021). However, on the other hand, these factors could encourage natural grasslands production due to resilience and resistance (NABINGER *et al*., 2009).

Two aspects resulting from the main threats are the reduction of the pastoral area, given that today the remaining grasslands in Uruguay occupy 64% of its original vegetation (CORTELEZZI; MONDELLI, 2014), and sheep production decreased from 26.5 million head in 1991 to 6.4 million in 2019 (OPYPA, 2019). This reality influences, for example, the conservation of biodiversity and, in the case of sheep, the weeding of fields.

When threats influence ecosystem services, alternative states and benefit delivery trends are defined (Table 1), i.e., resource availability and likely changes. Perceptions between researchers and producers are divergent (Figure 4) in most ES. However, there are points in which they coincide, namely the behaviour of outcomes in the carbon sequestration delivery trend and the likely change and loss of livelihood.

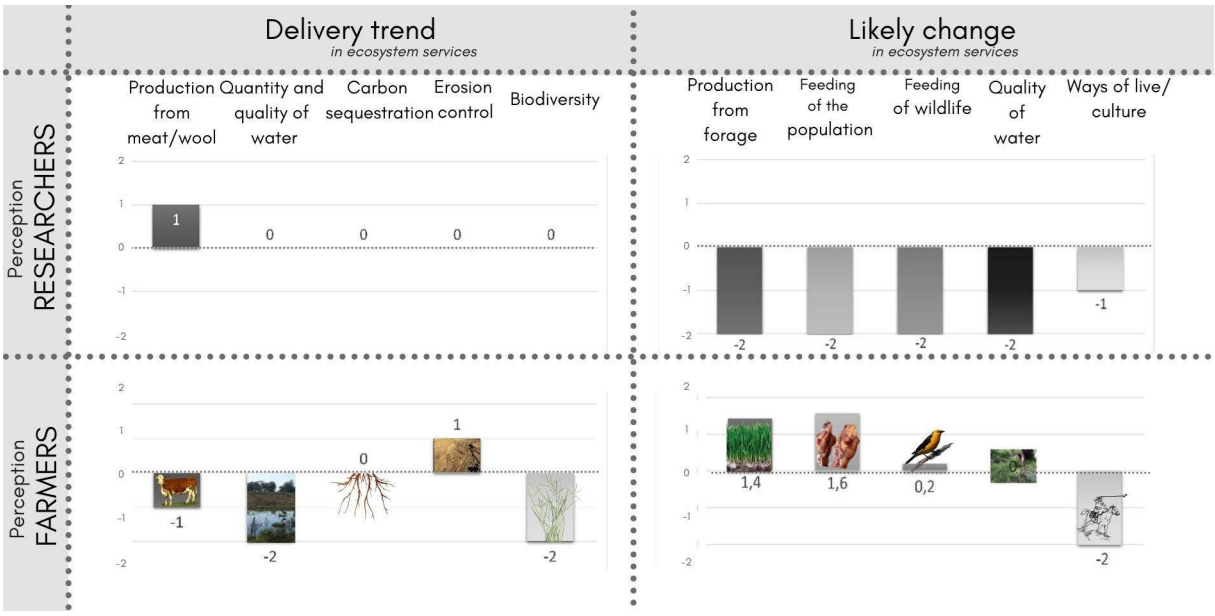

Figure 4 – *Result of the trend in delivery (next 5 years) of the five primary ES targeted and the likely change (10 years) perceived by researchers and producers (where 2 = large increase, 1 = small increase, 0 = no change, -1 = small decrease, -2 = large decrease).*

Source: Created by author

The increase in beef and wool production would be due to the adoption and dissemination of better production practices, greater access to technical advice, and availability of information and connectivity by producers in the field. On the other hand, the producers' vision is that, in addition to the increase in agriculture, the intensification of sown pastures and feedlots also suggest an increase in grain production, increasing the supply of this type of foodstuff for the population and livestock.

3.2 PERCEPTION OF THE MAIN ECOSYSTEM SERVICES AND THEIR DEGREE OF IMPORTANCE

According to the Millennium Ecosystem Assessment (2003, p. 30), ES are categorised into provisioning, regulating and supporting and habitat and cultural services. The provisioning category [1] was shown to have the highest number of services rated as necessary in both the researchers and the producer group: production of fodder (cattle and sheep feed), meat, wool and honey, water quality and quantity, medicinal plants, and genetic material.

The researchers scored all ES with the same degree of importance (value 5), and this behaviour occurred in most of the countries where the methodology was applied (SCHOSSLER *et al*., 2021).

The issue of water, its quality and quantity, for people, animals, and beneficiaries further away, such as city dwellers, was one of the most important benefits for all groups. Its importance aligns with the IPCC findings (2021, chapter 8), which concludes with high confidence that human-caused climate change has driven detectable changes in the global water cycle.

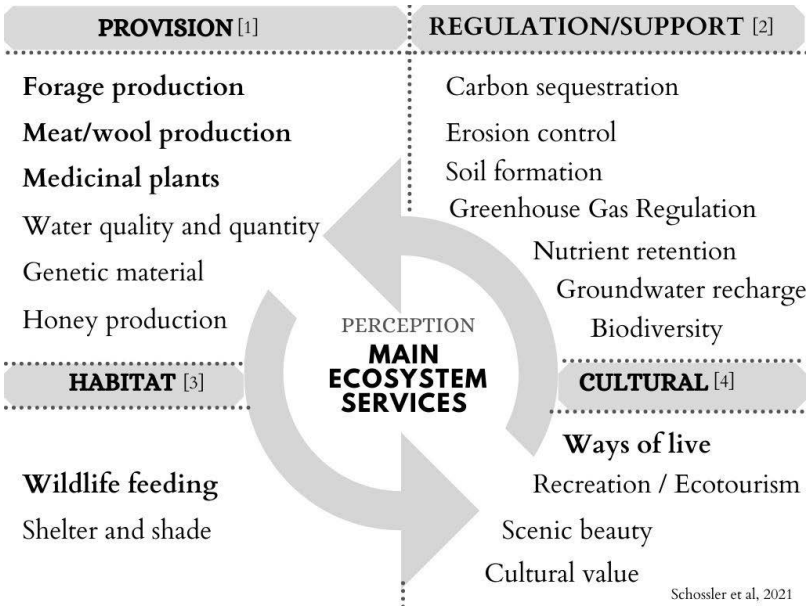

Figure 5 | Perception of importance of ecosystem services of Uruguay's natural grasslands subdivided into the four main groups (IPBES, 2015), Provisioning, Regulating and Supporting, Habitat and Cultural. According to the degree of importance (0-5), a) high degree (2.5-5.0); b) medium (0 - 2.5). Highlighted those that both groups cited.

Source: Created by author

Benefits that are more difficult to measure, such as biodiversity [2] and culture [4], are associated with habitat transformation, homogenisation, and disturbance (MODERNEL *et al*., 2016). Like this study, Cortés-Capano *et al*. (2020, p. 845) also revealed that landowners' management decisions and their primary needs are not primarily motivated by economic interests but also by cultural values, sense of place, relationship with nature, and traditional ranching. The main activity in the landscape of interest is extensive cattle ranching, which is traditionally associated with low productivity (OPYPA, 2017). However, a high cultural value is related to this type of ranching because the gaucho is the ecosystem manager (MODERNEL *et al*., 2018). Gorosábel *et al*. (2020) recently carried out an extensive literature review where it was found that studies related to values and immaterial, cultural contributions are scarce in the mentioned context.

On the impacts on soil conservation, both groups were clear that agriculture can maintain carbon sequestration and control erosion depending on the practices adopted. This is especially true when compared with overgrazing cases, which tend to be very common in traditional livestock systems. The benefits categorised as habitat [3] are forage for wildlife and shelter and shade for animals.

3.3 CONSERVATION ACTIONS

The actions noted that already occur in the territory of interest are related to technical and environmental assistance institutions (Snap and IPA) and the participation in development projects. This factor affirms the importance of governance processes in addressing conflicts of interest in using natural resources.

The producers' actions that are not occurring and are highlighted as necessary include the registration of native forests for tax exemption and the development of projects to promote better cattle ranching practices.

The positive impacts on nature include carbon sequestration, water quality, air purification, and the users and keeper's socio-cultural values in an integrated valuation of ecosystem services (MARTÍN-LÓPEZ *et al*., 2014) potentiates the success of projects and the application of recommended practices.

This is possible because this approach considers, as in any rural development strategy, the producer and their objectives as a central figure in decision making (NABINGER *et al*., 2009).

Generating data based on the integration of local stakeholders, institutions and technicians, with participatory consultations makes it possible to obtain a product with a high level of consensus among all participants. An example of this approach is the application of the Methodology for the participatory evaluation of rangelands (PRAGA) in Uruguay (CORTÉS-CAPANO *et al.*, 2020; FORMOSO *et al*., 2020).

4 LESSONS LEARNED FROM THE METHODOLOGY

The chosen area was suitable for two crucial aspects: homogeneity due to the same environment of natural grasslands with native riparian forests and the exact profile of the participants. There were productive discussions, given that they shared similar production challenges.

The inter-institutional nature of the work and the participation of the producers in other projects made it easier for the participants to perceive the importance of their contribution to the process. Returning the study results is essential for users to accept new participatory projects. In that case, a talk was presented at a cattle ranchers meeting, "Encuentro de Ganaderos", in October 2019, where a portion of the results was presented.

From the Tessa methodology

- Using the "alternative state": using this concept at the beginning of the engagement process was difficult for participants to understand. Therefore, it was decided not to present the "alternative state" map proposed in the Tessa guide. Instead, the alternative states emerged throughout the exercises, making the process easier.

- Regarding the quality of the map: the most user-friendly alternative for the producers was a printed satellite map from the Google Earth platform. For the producers' use, the document must contain the land use, the animal load, the floodable area, the agricultural area, and the surface soil area..

Regarding the workshop methodology

- Importance of sensitisation: the success of the work lies in the sensitisation of the stakeholders to the importance of activity results obtained. Important aspects utilised for this purpose were guaranteeing a publication with the data collected and the commitment to return the results.

- Number of participants: at most, 20 participants were divided into up to 5 working groups.

- Duration: based on the experience gathered in the other three countries, the total duration of the workshop of 5 hours achieves good results. However, it discourages participants before the end of the activities, which is crucial for finalising points of view.

5 CONCLUSIONS

Identifying the benefits and threats of the natural grasslands with an ecosystemic vision of production and conservation with the participation of resource users and researchers influences the adoption of sustainable management and strengthens arguments for decision-makers. The results generated in the workshops achieved the objective of identifying the ecosystem services and threats perceived by producers and researchers.

According to the users, the impact of the lack of incentives and primary structure (energy, connectivity, schools) in the countryside for rural people has profound consequences on the generational changes of livestock raising in Uruguay, which has a combination of livestock production and citizen well-being unique in the world.

The richness of the work was in learning and using the innovative application of the participatory method in pilot form and integrating the opinion of the users to solve the problems at hand. In addition, territorial governance and the in-depth analysis of institutions, such as IPA and Snap, regarding the different topics in the CJG facilitated the optimal use and advancement of the methodology.

Recognising the limitations of case studies with participatory methodologies, we consider our results positive and the method replicable. We believe this method to apply to more producer groups to contribute to the development of public policies to encourage the conservation of natural grassland ecosystems.

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Aplicación de metodología participativa para evaluación de servicios ecosistémicos en el bioma Pampa: lecciones aprendidas del método Tessa en Uruguay

Applying a participatory methodology to evaluate ecosystem services in the Pampa biome: lessons learned from the Tessa methodology in Uruguay

Daniela Schossler [1]

Carlos Nabinger [2]

Claudio Ribeiro [3]

Pablo Boggiano [4]

Monica Cadenazzi [5]

Diana L. Restrepo-Osorio [6]

[1] Máster en Gestión y Conservación de Suelos y Aguas, Doctoranda, Departamento de Producción Animal y Pasturas, Facultad de Agronomía, Universidad de la República del Uruguay, Paysandú, UruguayE-mail: tessapilotobrasil@gmail.com

[2] Doctor em Zootecnia, Profesor, Departamento de Plantas Forrajeras y Agrometeorología, Facultad de Agronomía, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil
E-mail: nabinger@ufrgs.br

[3] Doctor en Desarrollo Rural, Profesor, Curso Agronegocio y Zootecnia, Universidade Federal do Pampa, Bagé, Brasil
E-mail: claudioribeiro@unipampa.edu.br

[4] Doctor en Zootecnia, Profesor, Departamento de Producción Animal y Pasturas, Facultad de Agronomía, Universidad de la República del Uruguay, Paysandú, Uruguay
E-mail: prboggia@fagro.edu.uy

[5] Doctora en Zootecnia, Profesora, Departamento de Biometría, Estadística y Computación, Facultad de Agronomía, Universidad de la República del Uruguay, Paysandú, Uruguay
E-mail: monicade@fagro.edu.uy

[6] Doctora en Geografía, Universidad de Kansas; Servicio Geológico de los Estados Unidos (afiliación actual), Centro de Aguas en Kansas (USGS KWSC), Lawrence, Kansas, USA
E-mail: restrepita.diana@gmail.com

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ARTICLE – VARIA

RESUMEN

Identificar y medir servicios ecosistémicos involucrando actores locales tiene carácter novedoso en la literatura. El artículo describe el método utilizado en los talleres participativos, las lecciones aprendidas y los resultados específicos de la aplicación del método Tessa. La metodología fue aplicada de forma piloto con 56 investigadores y técnicos, más de 22 instituciones y 54 productores ganaderos involucrados con la iniciativa de conservación de campo natural, Alianza del Pastizal. Los agentes de cambio con mayor impacto, apuntados por los participantes, fueron la ausencia de trabajadores rurales, la falta de sucesión familiar, el enmalezamiento y sobrepastoreo de los campos. Los principales servicios ecosistémicos, producción de forraje, carne/lana, alimentación para fauna silvestre, modo de vida/cultura y plantas medicinales. La metodología es replicable, capaz de ser expandida a más grupos aportando al mejor conocimiento por parte de los productores de sus problemas y apuntando para la necesidad de desarrollo de políticas públicas de incentivo.

Palabras clave: Ganadería extensiva. Modo de vida. Percepción sociocultural. Campo natural. Políticas de incentivo. Conservación.

ABSTRACT

Identifying and measuring ecosystem services involving local stakeholders has been characterised as a novel approach in the literature. This article describes the methodology used in the participatory workshops, the lessons learned, and the specific results of applying the Tessa method. The methodology was piloted with 56 researchers and technicians, more than 22 institutions, and 54 livestock producers involved with the grassland conservation initiative, Alianza del Pastizal. Identified change agents with the most significant impact include the absence of a rural workforce, the lack of family succession, and weeding and overgrazing of grasslands. The primary ecosystem services identified included the production of fodder, meat/wool, wildlife forage, way of life/culture, and medicinal plants. The methodology presented here is replicable, capable of expansion to more groups, contributes to a better understanding, by the producers, of their problems and points to the need for the development of public incentive policies.

Keywords: Extensive livestock farming. Ways of life. Sociocultural perceptions. Native grasslands. Incentive-based policies. Conservation.

1 INTRODUCCIÓN

El concepto adoptado mundialmente para servicios ecosistémicos (SE) tiene carácter antropogénico: "*beneficios proporcionados por los ecosistemas a los seres humanos"* (MEA, 2005, p. 23). Sin embargo, en el desarrollo de políticas públicas, los actores locales, principales beneficiarios y mantenedores del ecosistema, no siempre tienen un papel central y omnipresente en la discusión de las problemáticas. Este enfoque subraya el papel de la cultura en la definición de todos los vínculos entre las personas y la naturaleza (DÍAZ *et al*., 2018).

Los campos naturales sudamericanos, templados y subtropicales, espacialmente heterogéneos (BERRETTA *et al*., 2000) constituyen la principal base forrajera del Uruguay siendo el recurso nutricional más importante para la ganadería de cría vacuna y ovina, constituyendo uno de los activos más importantes en términos de biodiversidad (MGAP, 2012). La diversidad de especies coexiste con el pastoreo, así como depende de él para mantenerse productivas y presentes. Dicha combinación proporciona una gama de valiosos servicios ecosistémicos que afectan el bienestar humano (VIGLIZZO; FRANK, 2006; WEYLAND *et al*., 2017).

Identificar servicios ecosistémicos con metodologías participativas, involucrando usuarios y beneficiarios de los campos naturales, tiene carácter novedoso en la literatura. Según el análisis hecho por Castillo (2019, p. 120) la América del Sur está dentro de las áreas menos estudiadas cuando se intenta encontrar publicaciones de la temática SE y las dimensiones sociales, "*dando voces a los diferentes actores".* La

mayoría de las investigaciones (61%) no tienen actores locales incluidos en ninguna instancia; de eso, solo 13% abordan los agentes de cambio (causas/factores de alteración del ecosistema natural).

El conjunto de herramientas para la evaluación de servicios ecosistémicos basada en sitio, Toolkit for Ecosystem Service Site-Based Assessment (Tessa), ofrece una guía accesible para métodos de bajo costo, que evalúan los beneficios que las personas reciben de la naturaleza en sitios particulares a fin de generar información que pueda usarse para influir en la toma de decisiones (PEH *et al*., 2017). Sin embargo, no tiene protocolos definidos para ecosistemas campestres y no propone un método para identificar e involucrar a las partes interesadas.

La metodología Tessa fue aplicada por primera vez en el ecosistema campestre en Brasil en el año de 2016 por Schossler (2016), después Argentina (SCHOSSLER *et al*., 2016A), Paraguay (SCHOSSLER *et al*., 2016B) y luego Uruguay entre los años de 2016 y 2020 con fondos de BirdLife Internacional. Las lecciones aprendidas presentadas en este artículo son resultado de la aplicación del método en los talleres participativos en los cuatro países con 56 investigadores involucrados con la temática, más de 22 instituciones y 54 productores participantes de la Alianza del Pastizal.

La Alianza del Pastizal (AP), es una iniciativa de fomento a la ganadería sustentable, trabaja para preservar los campos naturales, también llamados pastizales templados, entre las comunidades ganaderas en Uruguay, Paraguay, Argentina y Brasil. Uno de los proyectos es la certificación de predios con al menos 50% de la superficie con campo natural en buen estado de conservación (PARERA *et al*., 2014).

Los objetivos del artículo son a) Describir el método utilizado en los talleres participativos de evaluación de los servicios ecosistémicos y agentes de cambio como base para el desarrollo de la metodología Tessa; b) difundir las lecciones aprendidas en los talleres piloto en los cuatro países; c) dar a conocer los resultados del estudio de caso en Uruguay.

2 METODOLOGÍA PROPUESTA

2.1 IDENTIFICACIÓN DE LOS "STAKEHOLDERS"

En febrero del 2016, se realizó un taller piloto con profesionales y técnicos que trabajan en el área de campo natural, con el fin de informar sobre la metodología Tessa, como forma de evaluarla en Uruguay. También se discutieron las herramientas y las características que eran necesarias para la elección de los predios de estudio.

Se define el "sitio" de estudio, como la unidad de gestión o unidad potencial de estudio. El área potencial, puede ser un área protegida, importante desde el punto de vista de biodiversidad. El sitio debe ser una unidad de gestión operativa o potencial, como un área protegida o un área importante para las aves y la biodiversidad. Generalmente varía en tamaño de 100 a 100.000 ha, con límites entendidos por las partes interesadas.

Para elección del sitio se usó el histórico de certificaciones ambientales con el Índice de Conservación del Pastizal (ICP) utilizado y desarrollado por la Alianza del Pastizal (PARERA *et al*., 2014). En total se evaluaron datos de 215 predios certificados en Uruguay. Con los rangos de ICP más representativos del país, se eligieron propiedades cercanas entre sí unas de las otras, localizadas en un paisaje de importancia biológica, y con similitudes de campos y usos del suelo, así como el perfil de productores, ganaderos de campo natural. Mediante estos criterios se eligió la Colonia Juan Gutiérrez que cuenta con 30 propiedades certificadas y organizadas en la Sociedad de Fomento de la Colonia Juan Gutiérrez (SFCJG).

2.2 LOS ACTORES ELEGIDOS PARA EL ESTUDIO DE CASO EN URUGUAY

La *Colonia Juan Gutiérrez* (CJG) se ubica entre las latitudes 320 12.554´ y 320 7.530´ Sur y longitudes 570 15.198´ y 570 26.308´ Oeste, departamento de Paysandú, ciudad de Guichón. Tiene una superficie de 8.300 hectáreas, y aproximadamente de 30 predios, básicamente ganaderos, con un promedio de 300 hectáreas por predio. Los campos pertenecen al Instituto Nacional de Colonización (INC) y los productores son arrendatarios de estos siguiendo sus criterios.

La Colonia está ubicada en la confluencia de los ríos Queguay Grande y Queguay Chico donde se encuentra el Área Protegida con Recursos Manejados Montes del Queguay (Figura 1). Los límites del área protegida están definidos por el límite de la superficie de inundación potencial. La zona fue valorada para su ingreso al Sistema Nacional de Áreas protegidas (Snap) por su diversidad de ambientes destacándose su singularidad y bajo grado de intervención, así como sus elementos de interés para la protección del ecosistema y especies prioritarias para la conservación (MEDINA *et al*., 2019). La Snap apoya a los productores con la presencia de un guardaparque.

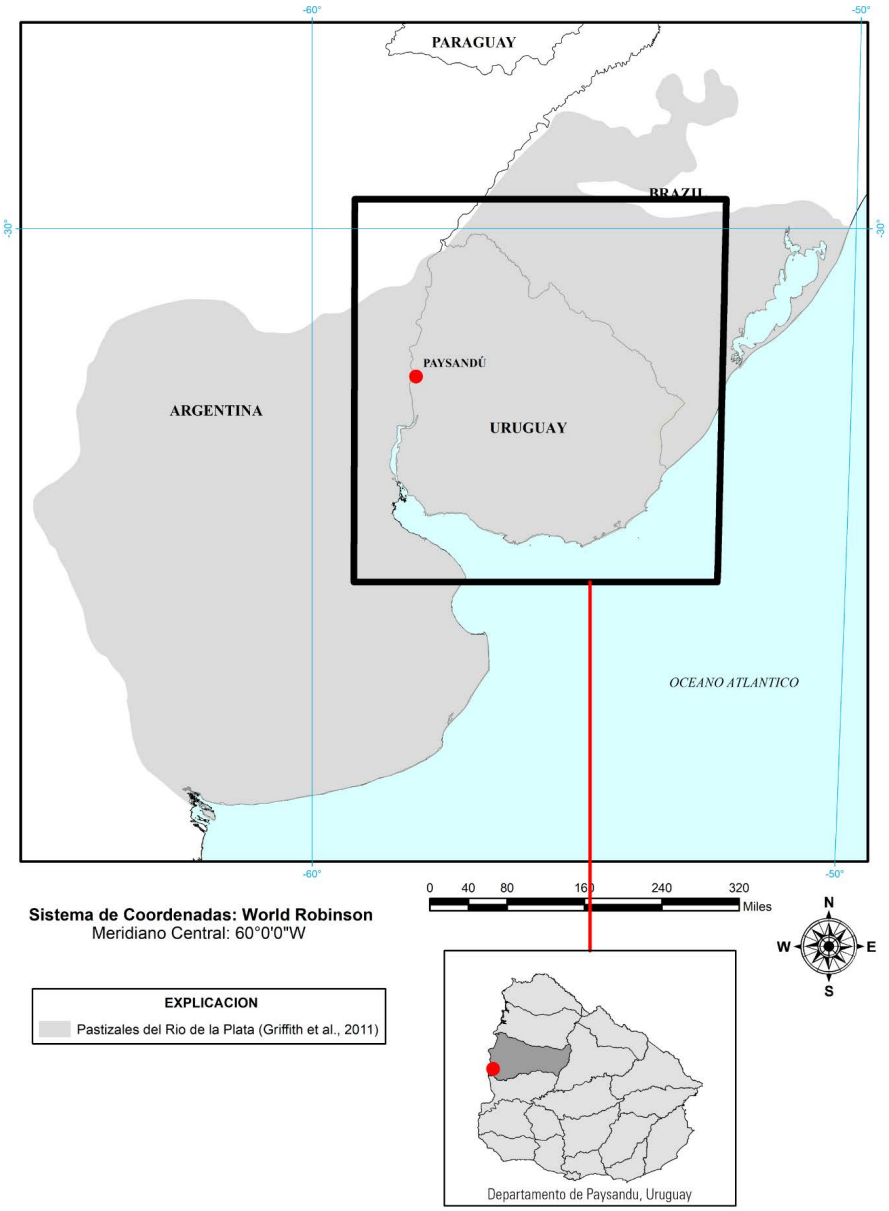

Figura 1 | Localización de la zona de estudio, Colonia Juan Gutiérrez, Guichón, Departamento de Paysandú, Uruguay. En gris la localización de los pastizales del Río de la Plata.

Fuente: Elaboración propia según Griffith et al., 2011.

La SFCJG, fundada en 1975, es la asociación de productores, donde cada participante mantiene su independencia jurídica y autonomía gerencial y participa voluntariamente en un esfuerzo conjunto (BÁEZ, 2005).

El Instituto Plan Agropecuario apoya, articula y desarrolla proyectos con la CJG y otras instituciones (MACHÍN, 2019) como Instituto Nacional de Investigación (Inia), Ministerio de Ganadería Agricultura y Pesca (Mgap) y Comisión Nacional de Fomento Rural, apoyados por la persona jurídica de la SFCJG.

La Alianza del Pastizal tiene un histórico de actuación junto a los productores de la Colonia. En el año de 2014, el Banco Interamericano de Desarrollo (BID) financió un proyecto donde 30 predios de la CJG fueron certificados con el ICP. Además de esa iniciativa el Inia y Nueva Zelanda desarrollaron el "Uruguay Family Farm Improvement Project" o «Mejora de la sostenibilidad de la ganadería familiar en Uruguay», entre los años 2013 y 2017, evaluando el ICP al principio y al final del proyecto.

2.3 PASOS DE LA GUÍA TESSA

Este artículo discute la ejecución del paso 2 del método Tessa (Figura 2), "*Evaluación preliminar de alcance"*, respondiendo las preguntas: a. ¿Qué cambiará en los servicios ecosistémicos como resultado de las decisiones de gestión (manejo)?, y b. ¿Qué impacto tendrá esto en los diferentes grupos de productores según los beneficios que otorga del sitio elegido?

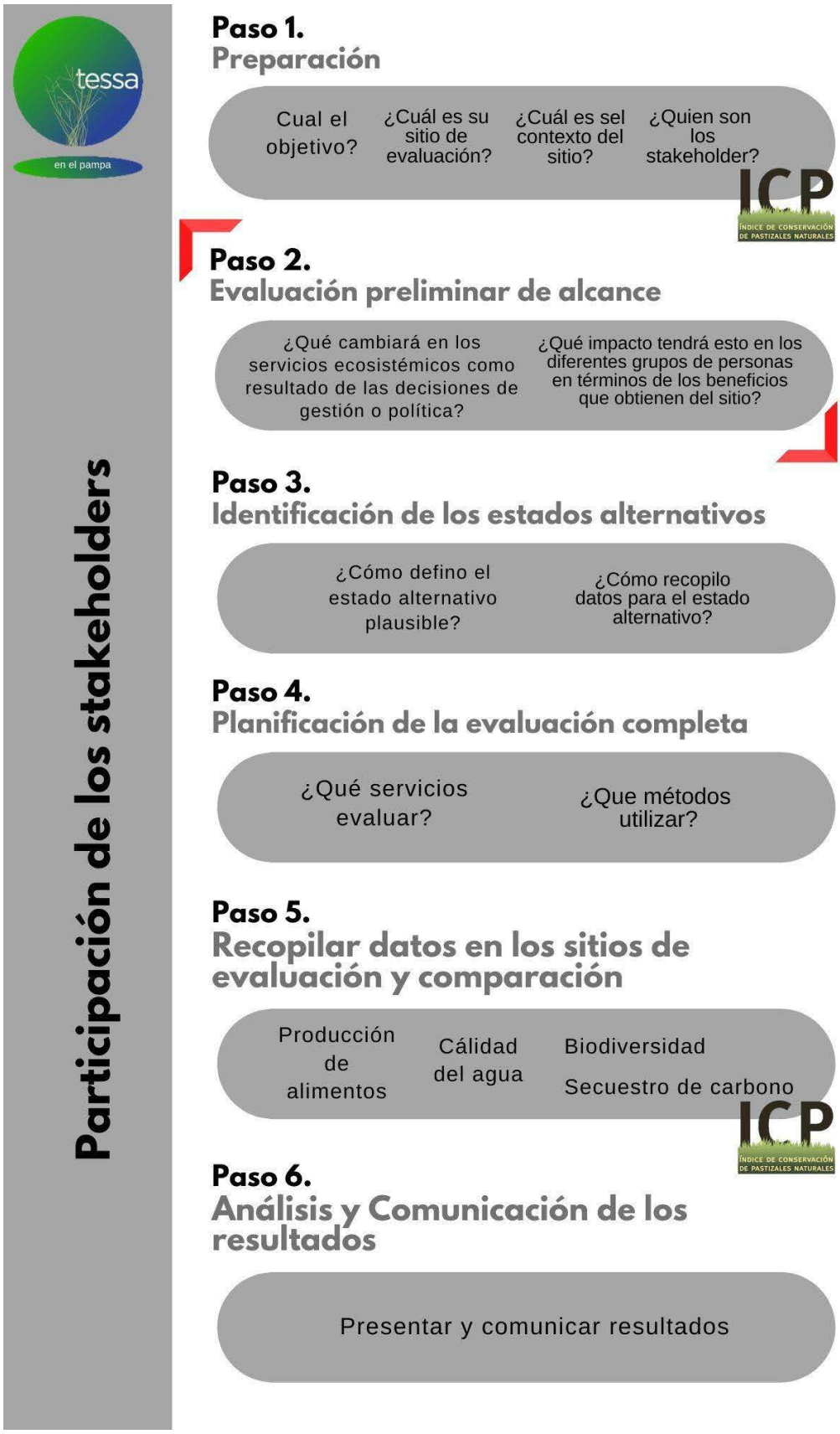

Figura 2 | Pasos de la metodología Tessa en el pampa y el uso del Índice de Conservación del Pastizal (Paso 1 y 5).
Fuente: Elaboración propia, adaptado de la guía de PEHL et al. (2017).

Los resultados esperados, además de posibilitar responder las preguntas para seguir los próximos pasos metodológicos, identifican los SE que serán evaluados en campo (Paso 5).

2.4 EL MÉTODO PROPUESTO PARA LOS TALLERES PARTICIPATIVOS

El método adoptado tiene tres etapas principales. Primero, la presentación y sensibilización sobre el tema central "servicios ecosistémicos". El segundo paso son ejercicios grupales abajo descritos y el tercero, discusión y generalización de la información relevante surgida del taller.

Las informaciones generadas son compiladas y evaluadas, generando gráficas de fácil interpretación, donde los actores pueden rápidamente identificar sus percepciones. Se comparan los cambios hipotéticos en los servicios de los ecosistemas y su distribución bajo un estado alternativo (si las amenazas apuntadas se establecen, como, por ejemplo, cambio por agricultura). Luego, se interpretan los resultados en relación con las posibles estrategias de gestión.

Parte 1: Presentación y sensibilización del tema

En un lenguaje sencillo y empático se hace una breve explicación de aproximadamente 30 minutos sobre el concepto, clasificación y ejemplos de servicios ecosistémicos, en los campos naturales.

Parte 2: Ejercicios grupales: Descripciones y tablas utilizadas para identificación de agentes de cambio y servicios ecosistémicos

Se dividen los productores en grupos pequeños de hasta 5 productores y cada grupo completa la tabla básica de información Tessa (completando la parte 1 y 2 descritas abajo). Se proveen hojas de trabajo con la explicación de los pasos a seguir con tablas (Tabla 1) para completar y un mapa de una propiedad representativa del área de estudio (en la cual están incluidos los actores participantes) con información como: el área total, áreas según tipo de suelo, número de potreros y uso actual.

El primer paso es *identificar el área ocupada por cada cobertura vegetal/uso* ya que muchos de los servicios ecosistémicos se ofrecen a nivel de hábitat y están asociados directamente según el tipo de cobertura vegetal. Luego, se realiza una clasificación de los principales hábitats, con información sobre tipo y porcentaje del sistema ocupado.

Identificación de las amenazas y los agentes de cambio

Además de la identificación de las amenazas y agentes de cambio, se estima el impacto de las políticas de gestión y acciones posibles de cambio por parte tanto de productores como de instituciones políticas de gestión y acciones positivas por parte de personas e instituciones.

Tabla 1 | Tablas utilizadas en los talleres para identificar agentes de cambio (amenazas), servicios ecosistémicos del estado actual y alternativo y caracterizar los probables cambios futuros.

Identificación de agentes de cambio (amenazas)				
Amenazas del sitio (presiones)	Tiempo (próximos 10 años) 1. Mayor a 4 años 2. En 4 años 3. Ahora	Alcance (proporción del sitio que es afectado) 1. Área pequeña 2. Algo del área 3. La mayoría del área	Severidad (ej. Grado de degradación del hábitat, tamaño del efecto) 1. Baja 2. Moderada 3. Alta	Impacto (Tiempo + Alcance + Severidad)
Identificación de servicios ecosistémicos (beneficios)				
Beneficios	Estado actual (Puntuación 0-5) 5 = muy importante	Cinco servicios priorizados en estado actual	Estado alternativo (Puntuación 0-5) 5 = muy importante	Cinco servicios priorizados en el estado alternativo
Caracterización de los principales servicios ecosistémicos				
Beneficios (5) priorizados de la tabla 2	¿Quién se beneficia? Local/Distrital/Nacional/ Global	¿Como ha cambiado la disponibilidad en los últimos cinco años? 2. Gran aumento 1. Poco aumento 0. sin cambio -1. Poca disminución -2. Gran disminución	¿Como cambiará este beneficio en el estado alternativo? 2. Gran aumento 1. Poco aumento 0. sin cambio -1. Poca disminución -2. Gran disminución	Cuales son los principales agentes de cambio (causa/factor) de ese cambio

Fuente: Elaboración propia

El primer paso es completado estimando los resultados de las decisiones posibles a corto y mediano plazo (dentro de 10 años, causado por las tendencias actuales en el sitio sin ninguna intervención para mitigar dichas tendencias), considerando a. ¿Cuáles son los agentes de cambio actuales y potenciales para el sitio en el corto o mediano plazo (ahora o en los próximos 10 años)?; b. ¿Qué tan inmediatos son estos cambios?; c. ¿Qué posibilidades hay para que estos cambios ocurran?; d. ¿Cuál es el alcance de estos cambios en los estos agentes de cambio los hábitats y biodiversidad del sitio en términos de área y cuál será la magnitud de dicho cambio (alcance)?; e. ¿Cómo afectarán estos agentes de cambio los hábitats y biodiversidad del sitio en términos de magnitud del efecto? (ejemplo: grado de degradación del hábitat, tamaño del efecto). Este escenario es denominado “estado alternativo”.

En el estado alternativo o escenario de cambios, es necesario enfatizar sobre los beneficios tanto productivos como sociales, ecológicos y económicos que conlleva la alteración del estado actual. Evaluar el servicio en particular es un paso útil para conocer los beneficios que estos brindan a las personas, pero es importante conocer las consecuencias sociales, ecológicas y económicas del cambio de su estado actual (conservado) en comparación con una alternativa plausible. Un estado alternativo puede ser la sustitución del campo natural por agricultura o una restauración del campo natural actual, por uso de diferentes planes de manejo y mejoras por agregado de insumos. Las evaluaciones del impacto resultante de los cambios en el uso de la tierra pueden ser más útiles para los tomadores de decisiones que los valores de un solo estado. Las evaluaciones comparativas pueden hacer explícitos los impactos sobre la biodiversidad y sobre servicios ecosistémicos; además pueden proporcionar información sobre quiénes se ven afectados (PEH *et al*., 2013).

Identificación de servicios ecosistémicos

Se entrega una hoja con una breve explicación de lo que son los SE, sus clasificaciones y beneficiarios y se empieza identificando todos los beneficios que proveen los campos naturales en la región de estudio. Para evaluar la gama de los servicios prestados por los sitios a nivel local, nacional y global, se enfoca en la definición e identificación de los servicios ecosistémicos con que se cuenta en estos predios, pero también permite el ejercicio de pensar sobre las contribuciones a nivel nacional y global. Para eso se utiliza la Tabla 2 en donde, en la primera columna, se califican todos los beneficios de 0-5. 0 = no relevante, 1 = de poca importancia, 5 = muy importante. Luego, a partir de los beneficios más altos en puntuación en la lista, se acuerdan cinco beneficios prioritarios para el sitio en su estado actual. En segundo lugar, hacer lo mismo para el estado alternativo (si las amenazas apuntadas arriba influyeron en el sitio) identificando los beneficios que podrán ser provistos en el estado alternativo y su importancia, medidos con la misma escala de 1 a 5. Como antes, se identifican cinco beneficios prioritarios para el estado alternativo.

Paso 3: Discusión en plenaria para elección de los servicios ecosistémicos más importantes

Caracterización de los principales servicios ecosistémicos, sus beneficiarios, cambios probables y agentes de cambio

Mediante la metodología de discusión grupal, se determinan los principales servicios que surgieron del trabajo grupal. Manejando los conceptos de trabajos grupales, se tiene especial cuidado en las ideas de no repetición y complementación de servicios, cuáles son más importantes y cuales están repetidos o se complementan. Se explican las preguntas de ese ítem y en plenaria se completan las respuestas.

Es fundamental asegurarse de que en la cuantificación de los SE no haya doble contabilización. Esto puede ocurrir si los procesos y servicios, así como los productos finales, se consideran todos componentes aditivos. Por ejemplo, el valor de la polinización y la regulación de las plagas de los cultivos son procesos beneficiosos que se manifiestan (procesos beneficiosos) a través del aumento de la producción de alimentos (un beneficio), por lo que, si no sería contabilizado el valor de la producción de alimentos en sí se cuantifica, la polinización de los cultivos y la regulación de las plagas no deben valorarse ni agregarse independientemente del total. Este criterio aditivo hace que se genere un modelo libre de duplicados y considerando que ingresen solo criterios aditivos (BALMFORD *et al*., 2011).

Lo importante de ese momento es redondear las informaciones y discusiones generadas en los grupos y llegar a los beneficios y amenazas más importantes, obteniendo las tendencias y cambios probables futuros.

El objetivo de esta etapa es lograr explicar un modelo de respuesta con una mejor relación de costos/ beneficios posibles.

2.5 TALLERES PARTICIPATIVOS

Taller piloto con investigadores y técnicos

A partir de un taller considerando 13 instituciones diferentes, mediante 18 delegados de formación docente, investigador y difusores del área de campo natural, se completaron los objetivos del método Tessa para posterior definición de focos de investigación y de difusión en el área estudiada. Con duración de 4h, se cumplieron los objetivos de adecuación metodológica para el trabajo posterior con productores foco de la investigación.

Taller con productores ganaderos locales

Este taller se realizó con 12 productores típicos ganaderos de la Colonia Juan Gutiérrez, docentes de la Facultad de Agronomía de la Universidad de la República del Uruguay, Snap y con el administrador y el director de la zona protegida y el presidente de la SFCJG. El objetivo de este segundo taller fue conocer la percepción de los usuarios y mantenedores del sitio elegido.

3 RESULTADOS Y DISCUSIÓN

3.1 PRINCIPALES AMENAZAS A CONSERVACIÓN DE LOS CAMPOS NATURALES, TENDENCIA EN LA ENTREGA Y CAMBIOS PROBABLES

La percepción de los ganaderos e investigadores se mostró fuertemente mediada por sus conflictos con la naturaleza, sentido de lugar y sus beneficios (CORTÉS-CAPANO, 2020; FAGERHOLM *et al*., 2020; GOLDSTEIN *et al*. 2012; RAYMOND *et al*. 2016; TALLIS y POLASKY, 2009). Por reconocer las interdependencias entre la producción ganadera y los sistemas ecológicos los agentes de cambios identificados (Figura 3) en este trabajo están vinculados al paisaje elegido para el estudio, sin embargo, demostraron resultados similares a otros estudios participativos (CORTÉS-CAPANO, 2020; FORMOSO *et al*., 2020) hechos en Uruguay, pudiendo extrapolar las informaciones a otros territorios.

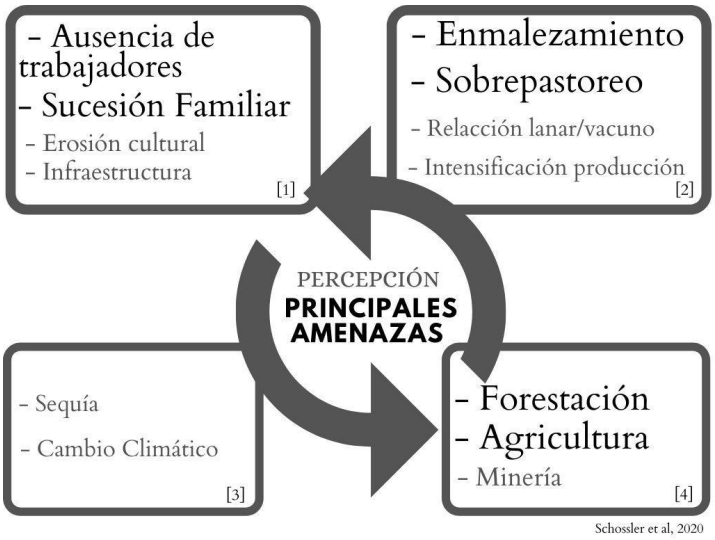

Figura 3 | Percepción de los actores involucrados en los talleres de las principales amenazas a la conservación de los campos naturales de Uruguay, agrupados por similaridad, donde los agentes de cambio con mayor grado de importancia aparecen destacados.

Fuente: Elaboración propia

El primer grupo [1] está caracterizado por las cuestiones sociales, donde la ausencia de trabajadores rurales y la falta de sucesión familiar tiene mayor impacto en la población rural. Los productores citan el tamaño de los predios (división de tierras por herencia), tenencia de la tierra y el envejecimiento de la población rural como principales factores para esas amenazas.

El bienestar apoyado por el paisaje está relacionado con múltiples elementos, o la falta de ellos, interconectados, que pueden informar las visiones colectivas de bien estar en el futuro (FAGERHOLM *et al*., 2020). Los grupos destacan, la preocupación con la erosión cultural (caracterizada por la pérdida de oficios), la despoblación en el campo y la desvalorización de la cultura propia. Si bien estos resultados son anteriores a la pandemia, el modo de vida de esas poblaciones ganaderas probablemente no cambió y además de eso, fueron refugios psicológicos y ambientales a las familias pues dado a que el país tiene

una población rural alta, según el informe mundial sobre la felicidad en el año 2021 (HELLIWELL, 2021), en Uruguay, el bien estar por persona, el bienestar promedio y la esperanza de vida he aumentado comparado a los años de 2006-2008.

Los cambios en la provisión de los SE pueden tener impactos muy diferentes en los individuos de una comunidad, ya que el acceso y el control de los recursos (y alternativas) está determinado por factores como la propiedad de la tierra, el género, la cultura, la etnia y el estatus social (DAW *et al*., 2011). Los problemas estructurales aparecen como alto impacto sobre la conservación, aunque son problemas asociados a falta de incentivos al sector. Esos problemas son caracterizados por la falta de energía eléctrica, conectividad y estado de las carreteras, también citados como amenazas por Formoso *et al*. (2020, p. 59).

Si bien los objetivos de conservación de la biodiversidad en este paisaje cultural no pueden perseguirse independientemente de los objetivos de desarrollo social (CORTÉS-CAPANO, 2020) los factores que afectan la producción como enmalezamiento y sobrepastoreo [2] son importantes para los actores mientras generalmente son respuestas a problemas de manejo e histórico de uso de los campos. A nivel nacional el Informe GEO sobre Estado y Perspectivas del Ambiente en el Uruguay señala (en 2009) que un 30% del territorio del país sufría algún grado de erosión y que los cultivos (ej. soja, arroz, maíz) son responsables del 87% de la superficie erosionada, y el sobrepastoreo del 12% (PÉREZ, 2020).

A nivel de campo, la presencia excesiva de algunas especies de plantas indeseables preocupa a los productores y técnicos. Las siguientes especies fueron citadas, en orden de importancia por el enmalezamiento/arbustización del campo y consecuente baja de la productividad ganadera, *Bacharis coridifolia* (mio-mio), *Eryngium horridum* (cardilla), *Eupatorium buniifolium* (chirca), *Baccharis trimera* (carqueja) y *Heimia salicifolia* (quiebra arados). Citadas como malezas, son especies nativas de los campos, y no pueden ser confundidas con especies exóticas invasoras (CEEI, 2014); su amenaza no se caracteriza por la presencia y si por la frecuencia, número de especies por metro cuadrado.

En una escala mayor, el cambio de uso del suelo, por actividades como forestación (RESTREPO-OSORIO, 2020) y agricultura intensiva [3], tiene alto impacto. Otra actividad que surgió fue la minería, sin embargo, no tan preocupante según los actores involucrados. La identificación de impulsores (directos e indirectos) que afectan los SE (DÍAZ *et al*., 2015) es urgente pues en los pastizales del Río de la Plata se verifica como unas de las más rápidas expansiones de fronteras agrícolas no solo en América Latina sino en el mundo (BAEZA; PARUELO, 2020), lo que lo hace uno de los biomas más modificados del mundo (BALDI; PARUELO, 2008; HANNAH, 1995; PARUELO, 2007).

Factores externos, no menos importantes, como sequía y cambio climático [4] son percibidos como amenazas y vienen de encuentro con la posibilidad de aumento de los eventos climáticos extremos con la previsión de incremento de 1.5 grados en la temperatura, diez años antes del previsto (IPCC, 2021) ocasionando una mayor frecuencia y / o intensidad de algunos fenómenos meteorológicos y climáticos. Esos factores podrían incentivar la producción en campo natural, por su resiliencia y resistencia (NABINGER *et al*., 2009).

Dos aspectos que resultan de las amenazas principales son la reducción del área pastoril, visto que hoy, los campos remanentes en Uruguay ocupan 64% de su vegetación original (CORTELEZZI; MONDELLI, 2014) y la producción ovina que disminuyó de 26,5 millones de cabezas en el año de 1991 a 6,4 millones en 2019 (OPYPA, 2019). Esa realidad influye, por ejemplo, en la conservación de la biodiversidad y, en el caso de los ovinos, en el enmalezamiento de los campos.

Cuando las amenazas influyen sobre los servicios ecosistémicos, se definen los estados alternativos y las tendencias de entrega de los beneficios (Tabla 1), es decir, la disponibilidad del recurso y sus probables cambios. Las percepciones futuras entre investigadores y productores son divergentes (Figura 4) en la mayoría de los SE, sin embargo, los únicos puntos que coinciden son el comportamiento de los resultados en la tendencia de entrega del secuestro de carbono y el cambio probable (pérdida) del modo de vida.

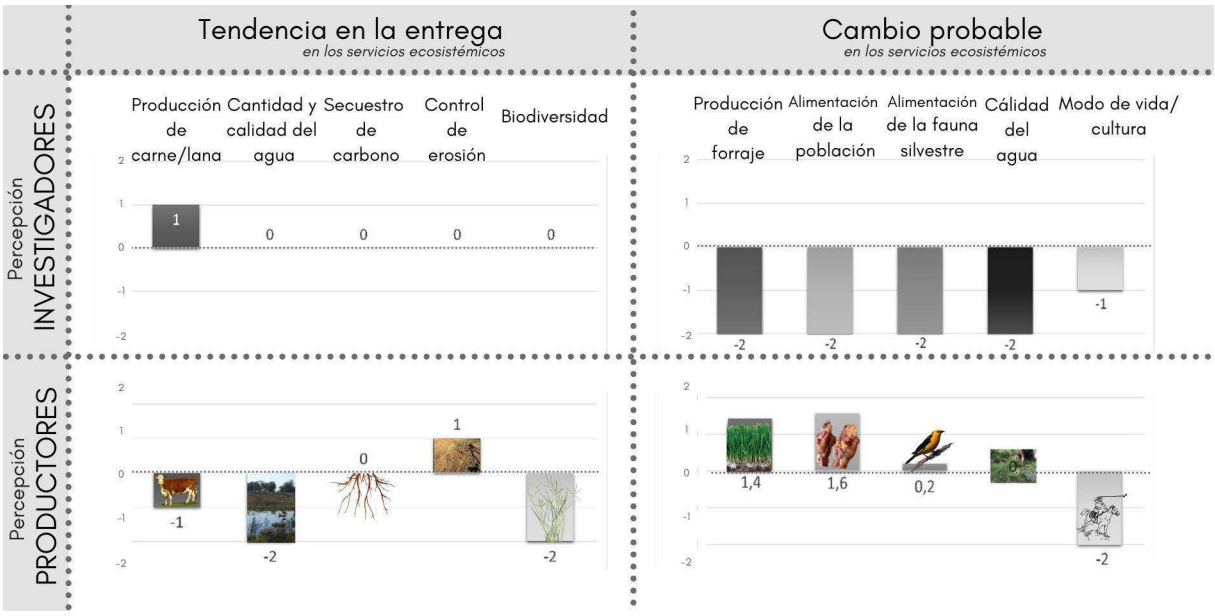

Figura 4 | Resultado de la tendencia en la entrega (próximos 5 años) de los cinco principales SE apuntados y el cambio probable (10 años) percibido por investigadores y productores (donde 2 = gran aumento, 1 = pequeño aumento, 0 = sin alteración, -1 = Pequeño decrecimo, -2 = gran disminución).

Fuente: Elaboración propia

El aumento de producción de carne y lana se daría por la adopción y difusión de mejores prácticas de producción, mayor acceso a asesoría técnica y disponibilidad de información y conectividad por los productores en el campo. Por otro lado, la visión de los productores es que, además del aumento del área de agricultura, existe también la intensificación de las pasturas sembradas y corrales de engorde (*feedlots)* que sugieren un aumento en la producción de granos, aumentando también la oferta de alimentos de ese tipo para población y animales.

3.2 PERCEPCIÓN DE LOS PRINCIPALES SERVICIOS ECOSISTÉMICOS Y SU GRADO DE IMPORTANCIA

Los SE según Millennium Ecosystem Assessment (2003, p. 30) son categorizados en servicios de provisión, regulación y soporte, hábitat y culturales. La categoría de provisión [1] se mostró con mayor cantidad de servicios apuntados como importantes en los dos grupos: producción de forraje (alimento para el ganado y ovejas), carne, lana y miel, calidad y cantidad de agua, plantas medicinales y material genético.

Los investigadores puntuaron todos los SE con el mismo grado de importancia (valor 5) y este comportamiento ocurrió en la mayoría de los países donde se aplicó la metodología (SCHOSSLER *et al*., 2021).

El tema agua, su calidad y cantidad, para las personas, animales y también para los beneficiarios más lejos como la ciudad, es uno de los beneficios más importantes para todos los grupos y su importancia corrobora con los hallazgos de IPCC (2021, capítulo 8), que concluye con gran confianza en que el cambio climático causado por el hombre ha impulsado cambios detectables en el ciclo global del agua.

Figura 5 | Percepción de importancia de servicios ecosistémicos de los campos naturales de Uruguay subdividido en los cuatro principales grupos (IPBES, 2015), Provisión, Regulación y Soporte, Hábitat y Culturales. Según el grado de importancia (0-5), a) alto grado (2,5-5,0); b) mediano (0 - 2,5). Destacados los que fueron citados por los dos grupos.

Fuente: Elaboración propia

Los beneficios que tienen mayor dificultad de medición como biodiversidad [2] y cultura [4] están asociados con la transformación, homogeneización y perturbación del hábitat (MODERNEL *et al*., 2016). Así como este estudio, Cortés-Capano *et al*. (2020, p. 845) también reveló que las decisiones de manejo de los propietarios de tierras y sus principales necesidades no son motivadas principalmente por intereses económicos sino también por valores culturales, sentido del lugar, relación con la naturaleza y la ganadería tradicional. La principal actividad en ese paisaje es la ganadería extensiva, culturalmente de baja productividad (OPYPA, 2017). Sin embargo, hay un alto valor cultural asociado a ese tipo productivo, el *gaucho*, gestor del ecosistema (MODERNEL *et al*., 2018). Gorosábel *et al*. (2020) en una extensa y reciente revisión bibliográfica encontró que los estudios sobre valores relacionados y los aportes inmateriales (culturales) son escasos para esos campos.

Otro aspecto importante son los impactos en la conservación de los suelos. Los dos grupos tienen claro que la agricultura, dependiendo de las prácticas adoptadas, puede mantener el secuestro de carbono y controlar la erosión y aún más si comparamos con los casos de sobrepastoreo, muy presentes en los sistemas ganaderos tradicionales. Los beneficios categorizados como hábitat [3] son alimentación de la fauna silvestre y abrigo y sombra para animales.

3.3 ACCIONES DE CONSERVACIÓN

Las acciones apuntadas que ya ocurren en el territorio están relacionadas con la presencia de las instituciones de asistencia técnica y ambiental (Snap e IPA), y por la participación en proyectos de desarrollo afirmando la importancia de los procesos de gobernanza en el abordaje de los conflictos de intereses en el uso de los recursos naturales.

Las acciones que no ocurren y son detalladas como importantes por los productores son el registro de monte nativo para exoneración de impuestos y el desarrollo y de proyectos de fomento de buenas prácticas ganaderas.

Los impactos positivos en/sobre la naturaleza como el secuestro de carbono, calidad del agua, purificación del aire entre otros, sumados a los múltiples valores incluyendo valores socioculturales de los usuarios y mantenedores en una valoración integrada de los servicios ecosistémicos (MARTÍN-LÓPEZ *et al*., 2014) potencializa el éxito de proyectos y de la aplicación de las prácticas recomendadas pues considera, como en cualquier estrategia de desarrollo rural, el productor y sus objetivos, como figura central en las tomas de decisiones (NABINGER *et al*., 2009).

Generar datos basados en la integración lograda tanto de actores locales como de instituciones y técnicos, con consultas participativas, permite obtener entre todos los participantes un producto de alto nivel de consenso como el ejemplo de la aplicación de la "Metodología para la evaluación participativa de pastizales (PRAGA) en Uruguay (CORTÉS-CAPANO *et al*., 2020; FORMOSO *et al*., 2020).

4 LECCIONES APRENDIDAS DE LA METODOLOGÍA

El área elegida fue adecuada por dos aspectos importantes: la homogeneidad (mismo tipo de ambiente, campo natural con montes nativos ribereños) y el mismo perfil de los actores. Resultó en buenas discusiones pues todos compartían los mismos desafíos en la producción.

La interinstitucionalidad del trabajo y de participación de los productores a otros proyectos hace que los participantes perciban con más facilidad la importancia de la contribución para el proceso. La devolución de resultados es una instancia importante para que los usuarios acepten nuevos proyectos participativos. En ese caso, se presentó una charla en el evento "Encuentro de Ganaderos" en octubre de 2019 con parte de los resultados.

Del método Tessa

Sobre utilizar el "estado alternativo": utilizar ese concepto al principio del trabajo es de difícil comprensión, por eso, se decidió no presentar el mapa del "estado alternativo" propuesto en la guía Tessa. Los estados alternativos fueron surgiendo a lo largo de los ejercicios, resultando más fácil el proceso de comprensión.

Sobre la calidad del mapa: la alternativa más comprensible a los productores fue un mapa satelital impreso (de la plataforma *Google Earth*). Para los productores, el documento tiene que contener el uso del suelo, la carga animal, el área inundable, el área agrícola y área de suelo superficial.

Sobre la metodología de los talleres

Importancia de la sensibilización: el éxito del trabajo está en la sensibilización de los actores en cuanto a la importancia de la actividad y los resultados obtenidos, seguridad de la publicación correcta de los datos y compromiso de devolución.

Número de participantes: en lo máximo 20 participantes divididos en hasta 5 grupos de trabajo.

Tiempo de duración: basado en la experiencia de los antecedentes desarrollados en los otros tres países, la duración total del taller con 5 horas logra buenos resultados y no se pierde participantes antes del final de las actividades, momento importante para el redondeo de opiniones.

5 CONSIDERACIONES FINALES

Identificar los beneficios y amenazas del campo natural, con una visión ecosistémica de producción y conservación con la participación de los usuarios de los recursos y también de investigadores, influencia en la adopción de manejos sustentables y fortalece argumentos para los tomadores de decisión. Los resultados generados en los talleres lograron el objetivo de identificar los servicios ecosistémicos y amenazas percibidos por los productores e investigadores.

Según los usuarios, el impacto de la falta de incentivos y estructura básica (energía, conectividad, escuelas) en el campo, y para la gente del campo, tiene consecuencias profundas en los cambios generacionales de la actividad ganadera en Uruguay, que tiene un perfil de vida y productivo, único en el mundo.

La riqueza del trabajo estuvo en el aprendizaje e innovación de la aplicación del método participativo de forma piloto, integrando la opinión de los usuarios en la problemática. La gobernanza territorial y la profundización de los distintos temas en la CJG por otras instituciones, como IPA y Snap, facilitaron los avances de la metodología.

Reconociendo las limitaciones de los estudios de casos con metodologías participativas, consideramos nuestros resultados positivos y el método replicable, capaz de ser expandido a más grupos de productores con el objetivo de aportar en el desarrollo de políticas públicas de incentivo a conservación del ecosistema campo natural.

AGRADECIMIENTOS

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Gender budgeting: a vital element for ensuring sustainable development

Orçamento de gênero: um elemento central do desenvolvimento sustentável

Olena Bilyk [1]

Veronika Karkovska [2]

Maria Khim [3]

[1] *Doctor of Science in Public Administration, Professor, Department of Administrative and Financial Management, Lviv Polytechnic National University, Lviv, Ukraine*
E-mail: olena.i.bilyk@lpnu.ua

[2] *Doctor of Science in Public Administration, Professor, Department of Administrative and Financial Management, Lviv Polytechnic National University, Lviv, Ukraine*
E-mail: Veronika.Y.Karkovska@lpnu.ua

[3] *Master's Degree in International information and management of higher educational institutions, Senior lecturer, Department of Administrative and Financial Management, Lviv Polytechnic National University, Lviv, Ukraine*
E-mail: Mariya.K.Khim@lpnu.ua

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ABSTRACT

The article aims to highlight the latest approaches to the introduction of countries gender budgeting. The authors propose the application of the method of ranking countries based on 4 key indicators related to the gender gap (Economic participation and opportunity, Educational attainment, Health and survival, Political empowerment) of the Global gender gap index and then analyse the result considering the level of socio-economic development of each country. Ten sample countries were randomly chosen. The results of the study confirmed the mutual influence between the gender gap and socio-economic development. The proposed method of ranking countries compared to socio-economic, political and environmental development allows countries with a high value of the gender gap index to offer specific tools to reduce it. The research conducted can help improve existing practices, facilitate initiatives to develop gender parity and further work on geographical and sectoral orientation.

Keywords: Gender gap index. Gender parity. Gender budgeting. Public policy effectiveness. World countries.

RESUMO

O objetivo do artigo é destacar as abordagens mais recentes para a introdução do orçamento de gênero dos países. Os autores propõem a aplicação do método de classificação de países com base em 4 indicadores-chave relacionados ao déficit de gênero (Participação econômica e oportunidade, Sucesso educacional, Saúde e sobrevivência e Empoderamento político) do índice de déficit de gênero global e, em seguida, analisam o resultado considerando o nível de desenvolvimento socioeconômico de cada país. Dez países foram escolhidos aleatoriamente como amostra. Os resultados do estudo confirmaram a influência mútua entre déficit de gênero e desenvolvimento socioeconômico. O método proposto de classificar os países pelo índice de déficit de gênero global em comparação com o desenvolvimento socioeconômico permite que os países com alto valor do índice de déficit de gênero ofereçam ferramentas específicas para reduzi-lo. A pesquisa realizada pode servir para aprofundar ainda mais as práticas existentes, facilitar iniciativas para o desenvolvimento da paridade de gênero e continuar a trabalhar na orientação geográfica e setorial.

Palavras-chave: Índice de déficit de gênero. Paridade de gênero. Orçamento de gênero. Eficiência da política de Estado. Países do mundo.

1 INTRODUCTION

A focus accompanies sustainable development on gender-related processes related to fundamental individual rights. Although a certain absence of consensus over the societal goals that would count as sustainable development (CONNELLY, 2007), gender equality is considered critical for the success of the 2030 Agenda for Sustainable Development, for which gender equality is fundamental (UN-WOMEN, 2020). Most developed countries are implementing the principles of gender equality to increase the effectiveness of public policies.

Relevant international institutions (United Nations Development Fund for Women, European Economic Commission) take gender into account in fostering sustainable economic development strategies. As a result, the concept of gender responsiveness in budgeting and the implementation of a gender-oriented budgeting strategy was developed (SHARP, 2003).

Sustainable development is not a technical problem that requires new technical means or technologies. This is the problem of changing social relations and forming a society that will not destroy its environment. Sustainable development is not a purely scientific problem. The transition to such a model of development has an ethical meaning. As said in the Our Common Future report: we need to go ahead and get success in elevating sustainable development to a global ethic status. It is a shift in the value orientations of many people. Like any social ideal, the concept of sustainable development is a guide for creating a society that will develop in harmony with nature, combining nature conservation and social development; satisfaction of basic human needs; achieving social equality and social justice; ensuring social self-determination and cultural diversity; maintaining the integrity of ecosystems and the renewal of natural resources, within a holistic approach at national, regional and global levels (WCED, 1987).

Since the World Conference on Women in Beijing in 1995 (UNITED NATIONS, 2001), social equality and social justice within sustainable development debates reinforced the mainstreaming of the gender approach, and this was established as the internationally agreed strategy to promote gender sensitivity in all planned action, law, policies and programs (MEZA, 2017).

Gender policies of austerity and competitiveness have strengthened feminist activism on economic issues. In a context of the dominance of economic criteria in policy design, it is thought that a gender-aware budget statement could indicate the extent to which the budget is gender-balanced (ELSON, 1998), facing the effects of a pretended neutrality of public budgets which favours gender inequalities.

This context called for new approaches to the planning and allocating income and expenditure at the state le. It promoted the idea of the gender impact of economic policies on the political and public debate (HIMMELWEIT, 2002).

Raising awareness of these ideas has sparked discussions about gender budgeting (GB): an increasingly popular strategy to promote gender equality through macroeconomic policies and budgets.

Gender-based budgeting is a strategy to achieve equality between women and men by focusing on the formation and expenditure of public resources. The Council of Europe defines gender budgeting as a gender budget assessment that includes a gender perspective at all levels of the budget process and restructures revenues and expenditures to promote gender equality policies (QUINN, 2009).

This approach to budgeting can improve it in cases where fiscal policy and administrative procedures are structured, taking into account gender inequality (AKHGASIEV, 2018).

The main purpose of gender budgeting is to integrate gender analysis into macroeconomic policies, government expenditures, and revenue proposals to promote gender equality. Based on this, the authors suggest ranking countries based on the Global gender gap index. The research aims to deepen existing practices further, facilitate gender parity, and further work on geographical and sectoral orientation. The expected results of the study are confirmation of the impact of the gender gap on socio-economic development. After all, underestimating the budget's impact on women and men can lead to a result that contradicts the objectives, making it impossible to achieve specific economic indicators, including economic growth, employment, and so on. After all, underestimating the budget's impact on women and men can lead to a result that contradicts the objectives, making it impossible to achieve specific economic indicators, including economic growth, employment, etc.

The purpose of this study is to apply a new method of ranking countries based on 4 key indicators related to the gender gap (Economic participation and opportunity, Educational attainment, Health and survival, Political empowerment) based on the position of the countries on the Gender gap index rank, and then analyse the result considering the level of socio-economic development of each country. The research conducted can help improve existing practices, facilitate initiatives to develop gender parity and further work on geographical and sectoral orientation.

2 AN OVERVIEW OF THE GENDER BUDGETING

Current research on gender budgeting worldwide and in Europe focuses on national contexts (KHAN; BURN, 2017; O'HAGAN; KLATZER, 2018). However, the goal of gender budgeting is political - to change macroeconomic policies and economic thinking, making gender and unpaid economies visible (HIMMELWEIT, 2002), which was taken as a basis by researchers. The study of the macroeconomic impact of the gender gap on the socio-economic development of countries and proving the relationship between these categories actualises the presented study.

Quinn (2018) presented an extensive analysis about gender budgeting in European countries: In Austria, Belgium and Spain, the national and regional governments have legislated gender budgeting policies, many have initiated changes in budgetary institutions (including Albania, Belgium, Iceland), while others have adopted the basic concept of marital equality policy together with economic policy (Sweden, Finland, Iceland).

In Austria, gender budgeting has been introduced as part of a broader budget reform process. As part of the reform, gender equality has become one of the four constitutional budgetary principles among transparency, efficiency and an accurate and fair view of the financial position of the Austrian federal government. These characteristics make the Austrian Gender Budgeting Initiative one of the most institutionally sound in Europe and perhaps provide a solid legal basis for improving implementation

methods to achieve more meaningful results of gender equality in line with socio-economic priorities (KORNIENKO, OSTRISCHENKO, 2016).

In Belgium, the law was introduced to make citizens more committed to gender issues. In the case of Belgium, the law provided for methods and processes for integrating gender equality into all budget processes, collecting and managing gender data, and specifying the goals of gender equality (KORNIENKO, OSTRISCHENKO, 2016). The Belgian initiative differed because it harmonised the ideals of gender equality with a system that covers all aspects of gender equality related to public policy.

Interesting in this area is also the experience of Sweden, where the introduction of gender in budget planning has taken place. At the same time, budget planning considering the gender aspect is fully implemented at the state level in all areas of socio-economic policy (KORNIENKO, OSTRISCHENKO, 2016).

Out of Europe, Budlender (2000) informed that in 1996 the Commonwealth Finance Ministers endorsed a recommendation to initiate a program on engendering budgets encompassing South Africa, Sri Lanka, Barbados and Fiji. According to her, several individual countries have also started to consider gender budgeting and the cross-country Commonwealth program: Namibia, Mozambique, Botswana, Tanzania and Uganda. The end of the 90s could also report a one-day workshop on gender analysis of budgets co-hosted by the British Treasury. All these reported events (the latter British experience, as well as initiatives in Canada and the United States of America, together with those in African countries and the four original movements within Commonwealth) could demonstrate that gender budgeting is of increasing concern worldwide and that it is not something relevant only to developing countries.

In many countries, gender budgeting has been used in difficult economic times to increase efficiency by reviewing the available resource and their more efficient use. Nevertheless, gender budgeting has also a political bias, highlighted by Galizzi, Bassani and Cattaneo (2018). For example, in South Africa, when forming the budget, among other things, racial analysis is carried out, which makes it possible to determine the share of public expenditures for the needs of white men and women and compare them with spending for other racial groups (BUDLENDER, 2005).

Thus, in the current conditions of the country's development, ensuring gender equality is a necessary component of forming a modern civilised socially-oriented society. Gender budgeting is an essential component and a valuable tool for increasing the socio-economic protection of the population, empowering women, and men, ensuring gender equality and developing democratic principles of governance (SHARPE, ALEXANDER, BAILEY, 1999).

Besides, gender budgeting initiatives are in line with the International Labor Organization's approach to gender and development with international commitments on gender equality, such as the Beijing Platform for Action (UNITED NATIONS, 2001), the Convention on the Elimination of All Forms of Discrimination against Women (UNITED NATIONS, 1979), the Millennium Development Goals and the 2030 Agenda (UNITED NATIONS, 2015a, 2015b).

Gender budgeting remains insufficiently covered, a general methodology for monitoring and implementing gender expertise of national and/or local budgets have not been developed, mechanisms for influencing government bodies and strategies for implementing a gender-balanced approach have not been put in place.

3 MATERIAL AND METHODS

For the last decade, the global community has come together to address the global gender gap, emphasising the economic aspects of gender parity. It is important to note that there is no single approach or model of gender budgeting. We deal with different actors (government, parliament or NGOs), different tasks, strategies, cultural traditions, levels of executive power, and other political

situations in other countries. Therefore, several authors have developed analytical tools that can be used in specific cases. The most popular and recognised in the world was the methodological development of gender analysis of the budget policy of the United Nations Development Program and the Secretariat of the British Commonwealth (BUDLENDER; HEWITT, 2003; IVANINA *et al*., 2016), which offers a methodology for 5 stages of gender budget analysis.

Among other known methods and approaches, it can be mainly (IVANINA *et al*., 2016, p. 21):

- "5 Steps by Debbie Budlender" is one of the earliest initiatives of gender-oriented budgeting in South Africa;
- "Three stages of gender-oriented budgeting by Sheila Quinn". These stages correspond to the entire cycle of processes required to apply the gender dimension as a category of analysis and control within the budget;
- "7 tools of Diana Elson" - a methodology developed by order of the Secretariat of the Commonwealth in 1999;
- "Method 4R" - a tool developed in Sweden in the 1990s and improved in the 2000s;
- "7 steps of gender budgeting" - a methodology proposed as a guide for implementing gender budgeting in Austria. This approach includes 4 phases and 7 steps of gender budget analysis.

The authors of the article analyse the global trends of the gender gap. It was concluded that gender analysis needs to be integrated into macroeconomic policies, government expenditures, and revenue proposals to promote gender equality.

Based on this, the authors suggest applying the method of ranking countries based on the Global gender gap index under new criteria, much more focused on the 4 key indicators related to the gender gap: Economic participation and opportunity, Educational attainment, Health and survival, Political empowerment, and then analyse the result considering the level of socio-economic development of each country. Thus, what is proposed here is to widen the focus to include hierarchical levels (key indicators with and without sub-indicators) and the socio-economic development context.

To do that, a sample of 10 countries from the total 156 countries analysed on the Global Gender Gap Report (WORLD ECONOMIC FORUM, 2021) was chosen.

The 10 countries were randomly drawn considering belonging to different continents, except Ukraine, which was the native country of the authors, and it was of central interest to check data.

Data from each selected country was obtained from individual Country Profiles in the Global Gender Gap Report (WORLD ECONOMIC FORUM, 2021).

The first step of the method involves the calculation of the Global Gender Gap Index for further comparison of countries' index with the original Global Gender Gap Index.

$$\text{Rating according to key indicators} = \begin{cases} F(x_n)\text{rank}, \\ Xn = \sum(X_1; X_2; X_3; X_4), \\ \downarrow F(x_n)\text{rank} = \uparrow S_{ED.} \end{cases} \quad (1)$$

where, $F(x_n)$ – Global gender-gap index;
X_1 – rank of Economic participation and opportunity;
X_2 – rank of Educational attainment;

X_3 – rank of Health and survival;
X_4 – rank of Political empowerment;
S_{ED} – socio-economic development.

The index and the rank based on this was generated in two different procedures, the first ones considering only the 4 key indicators with their sub-indicators (the whole system combining both the high hierarchical level indicators and the lower hierarchical level), and the second ones considering only the 4 key indicators without their sub-indicators (the system high hierarchical level only).

Later, countries were compared in terms of gender gap index and socio-economic development.

The comparison of the countries' rank with the socio-economic development is the last step. This step makes it possible to identify countries with a high level of the gender gap and low socio-economic development and further apply measures to implement the policy of budget systems of countries effectively.

4 RESULTS AND DISCUSSION

The 10 selected countries were: Azerbaijan, Lebanon, Ukraine, USA, Venezuela, Poland, Australia, United Arab Emirates, Germany, Japan). Their data were all obtained from the individual Country Profiles in the Global Gender Gap Report (WORLD ECONOMIC FORUM, 2021, p. 103, 107, 199, 233, 251, 323, 381, 383, 387, 393).

These countries were ranked according to: a) their original ranking system in the Global Gender Gap Report, and then their relative position about the 10 selected countries; b) the new ranking system considering the 4 key indicators with their sub-indicators; and c) another ranking considering only the 4 key indicators without their sub-indicators (Table 1).

For the last decade, the global community has come together to address the global gender gap, emphasising the economic aspects of gender parity. International experience shows that there are many different approaches to gender budgeting. The essential methods used in the various gender budgeting initiatives are the inclusion of gender aspects in the whole process of public financial management; integration of gender aspects into budgeting based on results and programs; categorisation of budget programs and requirements for gender analysis; a combination of gender budgeting and participatory budgeting; tracking financial allocations to promote women's rights and gender equality; application of standard gender budgeting tools, such as gender policy and budget assessment, separate gender analysis of public expenditure and analysis of tax revenues, as well as gender-sensitive assessment of beneficiaries' needs; gender budgeting; combining gender budgeting with impact assessments. Additionally, Alice Bauman-Dentener, when interviewed by Saito and Nogueira (2017), said that the major constraint to implementing Dublin Principle 3 recognising that Women play a central part in the provision, management, and safeguarding of water has been the lack of funding for Women's Civil Society Groups that work on the water-gender-development interface.

By its economic essence, the assessment of the efficiency of public expenditures allows us to determine how effective and rational are the activities and behaviour of spending units to achieve maximum results from the government (BILYK, 2020). The role of assessing the efficiency of public expenditures is to harmonise the interaction of all sections and components of the budgetary system for the rational use of budget funds and the achievement of relevant significant economic, social and other performance indicators (KARKOVSKA, VASIUNYK, 2016). The use of budget funds through the budget system is carried out mainly with one goal - to achieve the goals set in the economy and social policy and improve the environmental situation.

Although most countries have better opportunities to maximise women's economic potential, they cannot profit from their investment in women's education. In addition, very few countries are prepared to meet the challenges and take advantage of the gender parity resulting from the changing nature of work. Top 3 countries with the lowest gender gap are the USA, Germany, Poland (Table 1). Regarding

the ranking of countries according to key indicators, namely economic participation and opportunity, education, health and survival, political authority, the first three include countries like the USA, Germany, Poland (Table 1).

Therefore, it is essential to create a single platform for cooperation between the state and the private sector to resolve existing gender gaps and to change gender equality in the future: launching international scientific and practical measures to ensure the effective formation and distribution of gender budgets for countries and the exchange of experience with its implementation; development and implementation of programs/projects on the preparation of state and private sectors of the state for gender parity in the further work; providing a quantified commitment from leading organisations to increase labour opportunities and accelerate gender parity in the future; creation of a global knowledge-sharing platform to overcome the gender gap.

While addressing gender budgeting requires a complete process from gender budget analysis to gender mainstreaming throughout the budget process, it is essential to focus on the basic principles of budgeting for research, which is the basis and starting point for further work towards gender equality in resource allocation among different sections of the population.

The principles outlined in the Global Gender Gap Report highlight the approach to overcoming gender gaps based on rational and effective gender budgeting. The distinguishing feature of this Global Gender Gap Index is that it ranks countries according to their proximity to gender equality so that the highest possible score is 1 (gender parity) and the lowest possible score is 0 (imparity), for each index composing criteria (WORLD ECONOMIC FORUM, 2021).

Such a practice has a potentially transformative role, but the most effective is within the framework of a consistent strategy of state budgeting. For such an approach to work, public officials should, in the long term, commit themselves to manage some short-term barriers and trade-offs.

The main difference between this Global Gender Gap Index and the new one presented (Table 1) is that the second one is a positional index, which is more helpful in comparing countries than evaluating gender gaps. That's why all data concerning Index and Subindex, although based on Global Gender Gap Report, they represent the rank position of the country in each index and subindex, and not the gap index initially used to produce the final gender gap index presented by the World Economic Forum (2021).

Table 1 | Ranking of countries by the global gender gap

Index/ Subindex	*Azerbaijan*	*Lebanon*	*Ukraine*	*United Arab Emirates*	*Venezuela*	*Poland*	*Australia*	*Germany*	*Japan*	*USA*
*** Economic participation and opportunity**	36	139	44	135	112	63	70	62	117	30
Labour force participation	21	144	71	133	131	81	46	42	68	61
Wages equality for similar work	17	93	73	12	66	125	68	97	83	74
Estimated earned income (PPP, US $)	107	137	82	136	129	65	125	44	101	60
Legislators, senior officials and managers	58	122	31	120	78	28	46	94	139	29
Professional and technical workers	1	84	1	148	1	1	1	1	105	1
*** Educational attainment**	62	113	27	89	55	60	1	55	92	36

Index/ Subindex	Azerbaijan	Lebanon	Ukraine	United Arab Emirates	Venezuela	Poland	Australia	Germany	Japan	USA
Literacy rate	57	96	50	1	1	72	1	1	1	1
Enrolment in primary education	96	134	1	1	93	94	1	1	1	79
Enrolment in secondary education	110	1	1	127	1	1	1	113	129	1
Enrolment in tertiary education	1	1	1	-	1	1	1	1	110	1
* Health and survival	154	82	41	130	1	1	99	75	65	87
Sex ratio at birth	155	1	127	1	1	1	1	1	1	1
Healthy life expectancy	59	95	1	138	1	1	110	83	72	99
* Political empowerment	141	112	103	24	77	89	54	10	147	37
Women in Parliament	111	150	98	1	89	53	44	43	140	60
Women in ministerial posts	148	43	110	62	48	142	64	23	126	14
Years with the female head state (last 50 years)	76	76	44	76	76	37	43	6	76	76
Sum key index+subindex	1410	1623	906	1334	961	915	776	752	1573	747
Sum key index	393	446	215	378	245	213	224	202	421	190
Gender gap index	0,688	0,638	0,714	0,716	0,699	0,713	0,731	0,796	0,656	0,763
Rank Gender gap index report (global rank)	100	132	74	72	91	75	50	11	120	30
Rank Gender gap index report (regional rank)	23	6	14	2	24	15	4	7	18	16
Rank gender gap index report (sample)	8	10	5	4	7	6	3	1	9	2
Rank index+subindex	8	10	5	1	7	6	4	3	9	2
Rank index	8	10	4	7	6	3	5	2	9	1

Source: Calculated by the authors based on Global Gender Gap Report 2021 (WORLD ECONOMIC FORUM, 2021, p. 103, 107, 199, 233, 251, 323, 381, 383, 387, 393)

This method is appropriate because when considering countries in the overall ranking, it is pretty challenging to analyse the gender gap of one country about the total number of countries due to a large amount of data.

Table 2 | presents the comparison of the countries based on the new gender gap index and the socio-economic development Indicators.

Country	The efficiency of public expenditures	GDP (billion, $)	Value of population (women/ men)	Gender gap	Economic participation and ability	Education level	Health and survival	Rating according to the gender gap	Rating according to key indicators	Rating according to Efficiency of public
Germany	5,4	3000.78	1,02	0,796	0,706	0,997	0,972	1	2	3
USA	5,9	20000.81	1,02	0,763	0,754	1	0,97	2	1	2
Australia	3,6	1000.34	1,01	0,731	0,7	1	0,968	3	5	6
UAE	6,2	353.9	0,44	0,716	0,51	0,987	0,963	4	7	1
Ukraine	2,4	142.3	1,16	0,714	0,732	1	0,978	5	4	8
Poland	3,2	580.9	1,06	0,713	0,705	0,996	0,98	6	3	7
Venezuela	1,1	48.61	1,03	0,699	0,617	0,998	0,98	7	6	10
Azerbaijan	4,7	41.67	0,98	0,68	0,748	0,99	0,939	8	8	4
Japan	4,1	4000.91	1,05	0,656	0,604	0,983	0,973	9	9	5
Lebanon	1,8	18.73	0,99	0,638	0,487	0,964	0,97	10	10	9

** Note: Calculated by the authors based on 2021 World Economic Forum data (GLOBAL GENDER GAP REPORT, 2021)*

Determining the rating by such ranking methods allows determining the rating of one country about others on common grounds (which are on the same level): on the level of socio-economic development, on a territorial basis, for the population etc. The point is that those countries that meet these criteria are compared at the same level, or countries at different levels of development are compared. Through such comparisons, it is possible to assess the gender gap between countries and its role in socio-economic development. This is not done by the Global Gender Gap Report (WORLD ECONOMIC FORUM, 2021), which testifies that their gender gap index measures gender-based gaps in access to resources and opportunities in countries and not the actual levels of the available resources and opportunities in those countries, because they want to disassociate the Global Gender Gap Index from countries' levels of development (WORLD ECONOMIC FORUM, 2021, p. 72).

Research shows that countries taking steps to increase gender access to education, health, employment and credit, thereby reducing the gender gap in access to economic opportunities, point to accelerating economic development and poverty reduction. Financial liberalisation has also improved economic opportunities for women, in part through greater access to credit. As a result, the growth of macroeconomic indicators such as GDP, public spending efficiency, economic participation conditions, education levels and health indicators is essential.

The issue of responding to gender inequality concerns the social or psychological aspect and the economic one. Studies in 67 developing countries have shown that, on average, one in five men disagree that women have jobs outside the home, even if they are qualified. Inequality also persists in the legislation. At least one law in 155 countries restricts women's economic rights (RHODES; HARVEY; PARVEZ, 2017).

Significantly, achieving women's employment will boost the global economy by 5.8 trillion $, which will provide tax revenue growth of 1.5 trillion $. This increase will expand the emerging market opportunities (990 billion $) and developed countries (530 billion $) in North African countries, Arab countries and South Asian countries, as it is in these regions that the most significant gaps in participation in the workforce of women and men (INTERNATIONAL LABOUR OFFICE, 2017). Level of participation in the workforce and breaks in participation in 2017 - estimated data. According to recent data, gender inequality in developing countries is estimated at 9 trillion $ a year - an amount that will benefit not only women but also raise the purchasing power of different communities and provide a massive impetus for the development of the economy as a whole (OXFAM INTERNATIONAL, 2017). Why the majority of the world's poor are women). Empowering women requires the creation of decent

jobs for them, good opportunities for fair pay, and the increasing role of women in decision-making in power. With these targets in mind, the goal is to achieve full and productive employment, and decent work, for all women and men by 2030 (UNITED NATIONS, 2017b). This is vital for reducing poverty and achieving broader sustainable development goals.

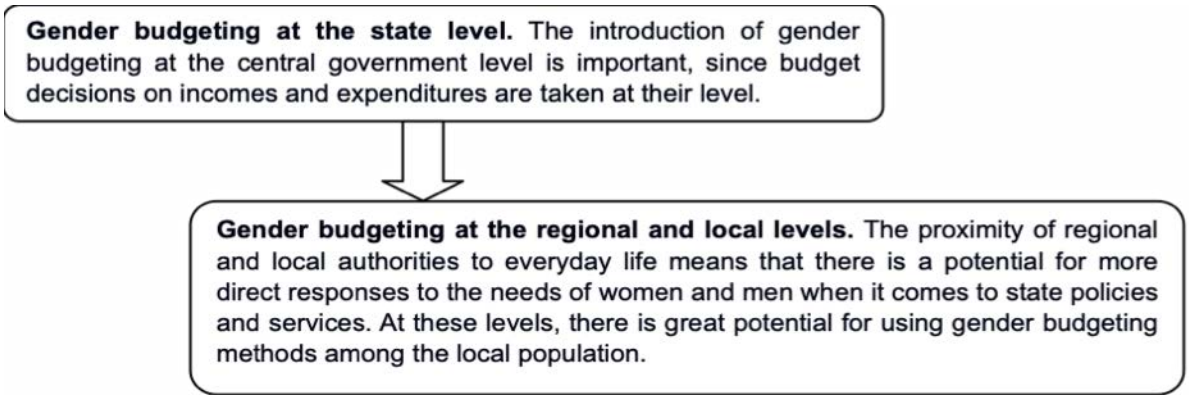

Figure 1 | Levels of gender budgeting*
**Information is taken from authors' sources*

Gender budgeting is a strategy for achieving equality between women and men, focusing on collecting and spending public resources. Gender budgeting is an approach that can improve when fiscal policy and administrative procedures are structured to address gender inequality. The introduction of gender budgeting will help save public money, considering the different needs of women and men (NIRAS, 2020). Gender budgeting can be applied to any budget system at all levels of government (Figure 1).

The effectiveness of gender budgeting involves implementing a political commitment in line with the technical capacity to implement gender policy (Figure 2). Management decision-making should focus on ensuring gender mainstreaming in the planning and budgeting processes and the income and expenditure of the state budget for the benefit of women and men alike. A good example can be found in Ukraine, where MAMA-86, an environmental, women's and social justice organisation, has lobbied and worked with the Ukraine government successfully supporting the design of a legal framework on water and health issues, including the National Environment and Health Action Plan (2001), the Law on Drinking water (2002), the program on "Drinking Water of Ukraine" (2005), and the national targets for the Protocol on Water and Health (2011) (BOUMAN-DENTENER, 2017).

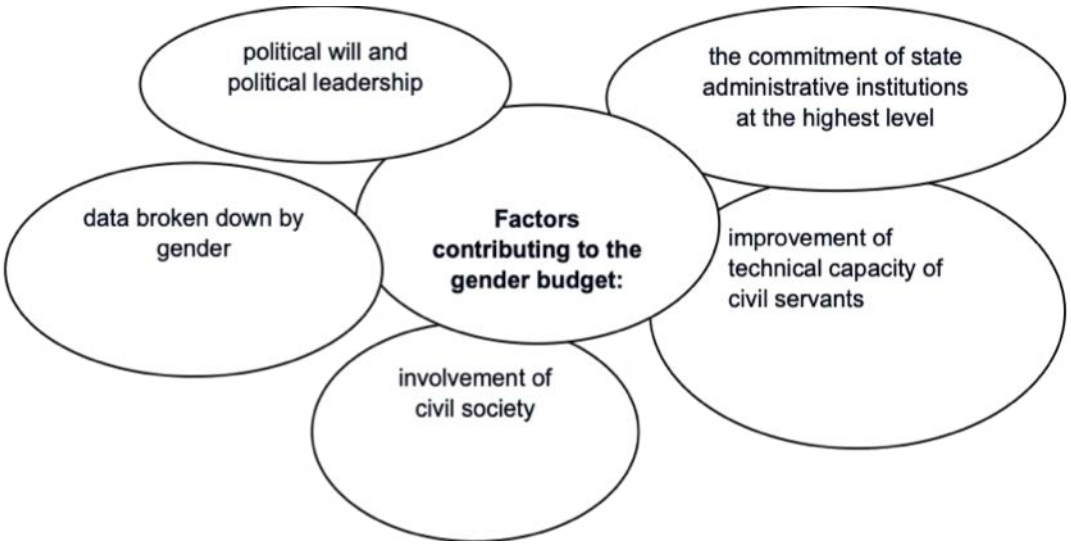

Figure 2 | Factors of gender budgeting promoting*
**Information is taken from authors' sources.*

Political will and leadership are based on an active political stance to promote gender equality and ensure development. Features of the political will factor are:

- increased awareness of key actors such as higher authorities, political parties, regional and local assemblies, and advisory bodies;
- public support for gender-sensitive budgets;
- Policy recommendations on gender budgeting;
- Gender mainstreaming in the budget and related policies.

Equally important is the commitment of top-level state administrative institutions, which is characterised by the implementation of clear instructions on the performance and follow-up of civil servants in fulfilling their gender equality commitments.

Improving the technical capacity of civil servants to implement gender budgeting policies and recommendations should be coupled with the political will of the civil service and the pursuit of gender equality to ensure that ambitions and competencies are matched.

Civil society plays a crucial role in ensuring that the state is held accountable for meeting international and national commitments to gender equality. It can also play a vital role in linking the state and society and facilitating participation in budgetary processes.

Gender-disaggregated data is a favourable factor in gender budgeting. Therefore, a reliable statistical system and management information systems in government institutions, structures and research institutes are critical.

In gender budgeting, the principles underlying the high-quality budget process play an essential role (Figure 3). Current public financial management standards include principles such as performance orientation, transparency, accountability, etc.

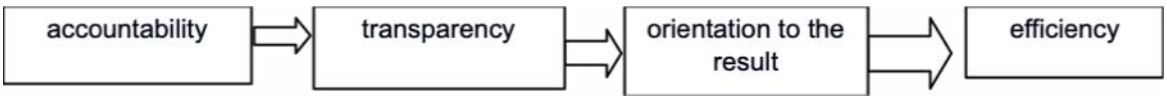

Figure 3 | Principles for implementing gender budgeting*
**Information is taken from authors' sources.*

Gender budgeting analyses the impact of budgets on women and men, which is also considered an essential part of monitoring how the budget works towards achieving gender equality goals in the country. Implementing the gender budget will make the state accountable for its gender policy commitments, civil society and the media and play an essential role in monitoring and ensuring government accountability for their budgets.

Gender budgeting should be taken into account for transparency. Increasing participation in the budget process can be achieved by introducing public consultation practices and participation in budget preparation or public involvement in budget monitoring.

Performance-based budgeting brings strategic planning and public finance closer together, linking policy goals more closely to budgets. This is done by defining goals, objectives and activities and creating a monitoring system based on performance indicators to measure progress. A proper, results-oriented approach only happens when gender budgeting is integrated into budgeting for implementation. Gender budgeting helps improve information on the potentially different situations and needs of women and men and the impact of the allocation and impact of resources on women and men. Thus, gender budgeting provides the basis for better and more informed decision-making. This, in turn, contributes to more efficient use of public funds and increased control over the system of budget formation and distribution.

International experience shows that there are many different approaches to gender budgeting. The essential methods used in various gender budgeting initiatives are:

- gender mainstreaming in the entire public finance management process;
- gender mainstreaming in results- and program-based budgeting;
- categorisation of budget programs and requirements for gender analysis;
- combining gender budgeting and participatory budgeting;
- tracking financial allocations to promote women's rights and gender equality;
- the use of standard gender budgeting tools such as gender policy and budget estimation, gender-disaggregated public expenditure and tax revenue analysis, and gender needs assessment of beneficiaries;
- gender budgeting;
- combining gender budgeting with impact assessments.

Based on the study of gender budgeting results, the following conclusion can be drawn: identifying gender gaps (gender-discrimination, negative trends) in meeting the needs and interests of women and men and restoring parity. An analysis of the detection of gender gaps in different countries was carried out (Figure 4), confirming the authors' hypothesis that the increase or decrease of gender gaps is directly proportional to the level of budgeting costs.

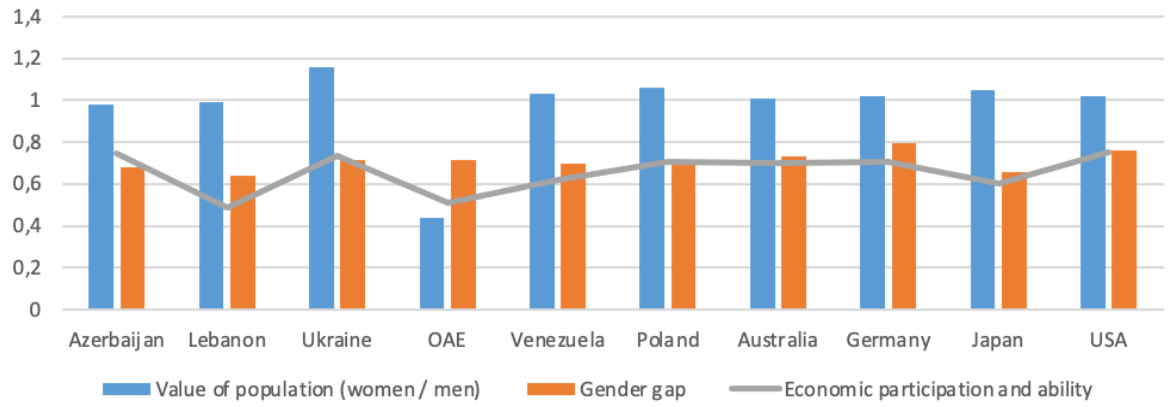

Figure 4 | Dynamics of Gender Parity Change in the World in 2021*
*Information is taken from authors' sources.

To ensure decent work, including adequate income, secure contracts and safe working conditions, governments and businesses should consider the quality and security of women's economic opportunities. This requires:

- an assessment of current labour standards and wage rates to ensure that the legislative labour standards cover homeworkers, migrant workers and informally employed workers;
- legislative solutions to the problem of violence and discrimination in the workplace;
- consulting with employees and trade unions on raising the minimum wage as compared to the living wage;
- provide concerted efforts to close the pay gap, including ensuring equal pay for work of equal value and promoting decent work for women;
- repeal laws that discriminate women's economic equality and introduce legislation and a legal framework that supports women's rights;
- promoting positive social norms and attitudes towards women's work, restoring the balance of power in the household, at the local, national and international levels;
- providing women with access to more paid positions, as well as improving access to education and training;
- promoting transparent ways for policies that encourage employers to hire and train low-skilled employees;
- recognise, reduce, and redistribute unpaid homework;
- governments should invest in state services and infrastructures that reduce and redistribute unpaid care work, including general free public health, social assistance, child care, water and sanitation, and education services;
- governments and international financial institutions should incorporate unpaid care work within their economic development strategies;
- governments and the business community should recognise the high responsibility of women for unpaid care work and provide flexible working hours and paid parental leave;
- governments should be encouraged to redistribute unpaid care work based on policies that encourage men to do their fair share. These include flexible work schedules and parental leave for both parents. Social rules on the distribution of responsibilities of men and women for care work, for example, through advertising or public campaigns;
- governments and international institutions should collect more accurate data on the distribution of unpaid care work and its contribution to the economy as a whole.

Also, governments need to increase fiscal space for women's economic empowerment through a progressive scale and gender-sensitive tax policies, help overcome tax evasion by large corporations and individuals and use this extra income to invest in state services.

As part of the scientific search for managing social risks innovative mechanisms, we note that gender differences are differences not only in gender but also in specific needs due to mental, social, ethnic, racial, religious differences.

However, considering current trends, it can be argued that today the application of gender-based budgeting cannot cover the entire budget process due to financial constraints. Thus, in 2020 there are 930 gender-sensitive passports, compared to 325 in 2019 (MINISTRY OF FINANCE OF UKRAINE, 2021). It is also essential that the existing constraints on program funding require the development of a methodology. Taking into account the above, the stages of gender-oriented budgeting have been improved (Table 3).

Table 3 | The process of improving the gender-oriented budgeting stages implementation in terms of sustainable development

Stages	*Substages available in the methodology*	*Proposed substages*
1. Assessment of the initial situation and opportunities for work in a particular area	1.1 Stakeholder analysis. Identification of target groups and beneficiaries	It is necessary to apply SWOT analysis, which will consider the strengths and weaknesses, opportunities and threats within a particular local community or a specific program.
	1.2 Assessment of organisational and personnel prerequisites for implementation	It is necessary to add the information policy analysis in gender-oriented budgeting construction (by surveying the population, analysing information in the media, etc.)
	1.3 Compilation of a "gender profile."	It is necessary to add a qualitative data retrospective analysis in a particular area (in the course of decentralisation, it is essential to structure mental, geographical, religious, ethnic features).
2. Conducting gender budget analysis (industries/programs, activities) according to gender differences	2.1 Estimation of services cost	It is necessary to structure people by age.
	2.2 Estimation of personnel costs	Similarly, it is necessary to analyse the age structure of staff
	2.3 Industry/program funding comparative analysis by years	Application of comparative analysis with other regions, programs, countries and construction of trends
	2.4 Evaluating the services effectiveness	Application of service efficiency qualitative evaluation (surveys, questionnaires)
3. Identification of gender-specific issues, goals and objectives	3.1. Analysis of existing facts of gender inequality, as well as policy decisions and measures that exacerbate such inequality	It is advisable to analyse the information policy regarding a specific program or territorial unit
	3.2 Formation of gender-specific goals and objectives of budget policy aimed at solving gender-specific problems	It is necessary to identify the preconditions for gender inequality
4. Formation of gender-sensitive budget proposals	4.1 Identify measures within the sector/program budget that will contribute to gender equality	In the conditions of limited financial resources, it is necessary to apply A / B - testing that will considerably simplify the implementation of all previous stages

* Improved by the authors based on (MINISTRY OF FINANCE OF UKRAINE, 2021)

These steps are necessary for the initial implementation of gender-based budgeting. But in the future, it is proposed to use A / B testing to select gender-sensitive programs. Also, the use of this method is crucial in the conditions of Covid-19 because it is based on the use of digital technologies. A / B testing offers a very systematic way to determine the effectiveness of any process. This test is based on the application of marketing technologies in the digital economy. Most marketing efforts are aimed at increasing traffic. In particular, in the case of expanding the application of the gender approach, we can consider the efforts of its supporters through the prism of marketing and position it as an effective way to minimise social risk and improve the socio-economic situation in the country. Focusing on digital space requires flexibility in gender-based budgeting and traffic expansion. However, because purchasing traffic is complex and costly, it becomes a top priority to offer the best experience to stakeholders who visit gender-based budgeting websites. This will help them achieve their goals and perform the conversion in the fastest and most efficient way. A structured A / B testing program can make marketing efforts more profitable by identifying the most critical problem areas that need to be optimised and applied to gender budgeting. In the practice of commercial enterprises, the application of A / B testing moves from independent activity, which was limited to the frequency of once a month, to a more structured and continuous, which should always be carried out through a clearly defined process. Usually, in A / B testing, only two possible programs or directions are used, but the variety of potential programs should be considered.

It is necessary to use digital technologies to define and optimise processes in conditions of quarantine restrictions. A / B Testing (also known as Separate Testing) is a website optimisation technique that sends half of the users to one version of a page and the other half to another and viewing web analytics to see which one is more efficient. However, through this testing, it is possible to determine the effectiveness of applying gender-sensitive scenarios in the public management system of social risks. The application of A / B testing is summarised in Figure 5.

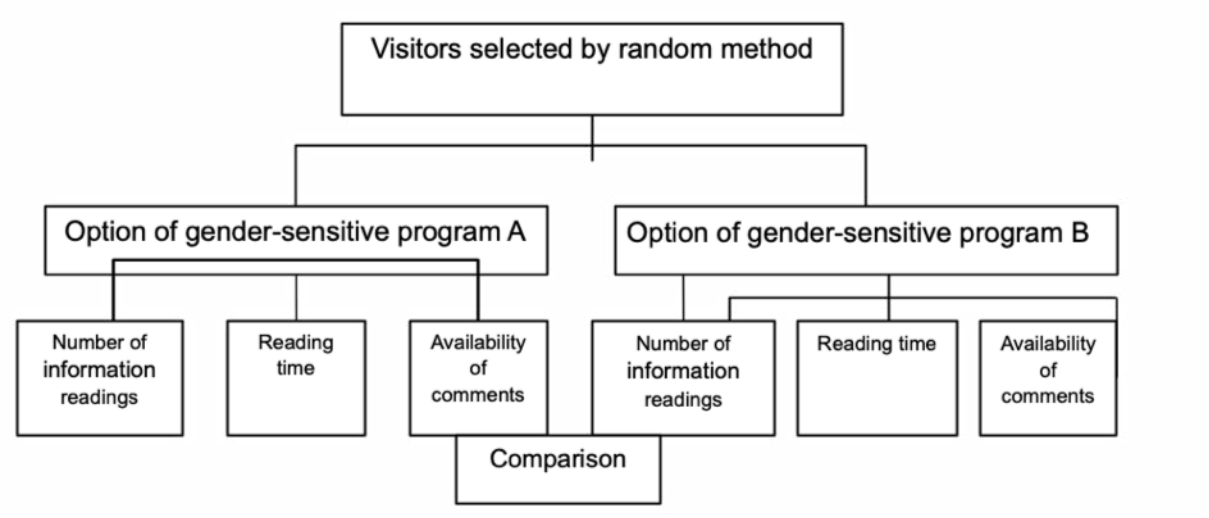

Figure 5 | Generalized scheme of A / B-testing application for gender-sensitive programs construction

Google Analytics and Google Optimize offer one of the best data collection and A / B testing solutions. It allows getting almost everything you need for free. The Google Analytics 360 suite includes 360 optimisations and provides a wide range of tools in the free version. However, it is essential to have a professional who knows how to set up advanced tracking. This is the main disadvantage of Google: you need to know the platform and how to get the most out of it. It will require appropriate technical training. This type of testing will significantly simplify identifying gender-sensitive budgets or those

areas that need the most intervention or are the least gender-sensitive. Table 4 projects the steps for implementing A / B testing for gender budgeting.

Table 4 | Proposed stages of A / B testing implementation for gender budgeting

Stage	*Description*
Testing goals	Increasing readership, increasing subscriptions, increasing visitors' time on the website, or speeding up viewing of videos and other materials using social sharing
Measurement	Testing program planning
Setting priorities	Prioritisation helps to sort several hypotheses scientifically. At this point, you should get website data, visitor data and clearly define the goals, taking into account the lag in the first stage.
Terms	Precise time measurements of testing, the randomness of the study (random approach), continuity of tests (ie sampling should be constant). Considering those options that did not work. The sample (hypothesis) must have a causal relationship.
The concretisation of testing measurements	Specific social button, which is available in public institutions (eg Center for Administrative Services). Testing of registration methods by e-mail
Compiling a testing calendar	An effective optimisation program will always have two parts: planning and setting priorities
Making changes	Analysis of all the results, changes.
Efficiency	Choosing the best option for a gender-sensitive social program. A more efficient process of analysing gender data. Raising public awareness.

Reducing gender inequality can improve macroeconomic indicators. Recognising that gender differences are harmful and state budgets are not gender-neutral means that gender considerations need to be included in the budgeting process. Although gender budgeting initiatives can take many forms, their most important purpose is to influence the budgeting process and help policymakers focus on how public policy can help reduce gender inequalities and improve economic performance.

It is essential for the study and development of gender parity:

- understanding current gaps, recognising bias, setting goals, and reporting on the benefits of promoting gender parity in organisations or structures;
- making changes in the design of programs/budgets, namely overcoming gaps, such as payments, parental leave, productivity reviews, hiring processes, mentoring, sponsorship, training in security and governance, etc;
- expanding initiatives beyond the boundaries of specific areas and promoting change in industries, communities, value chains and the wider society.

5 CONCLUSIONS

The results of the study confirmed the impact of the gender gap on sustainable development. By reducing the gender gap, countries can achieve the UN's sustainable development goals. The proposed method of ranking countries by the index of the global gender gap allows countries with a high value of the gender gap index to offer specific tools to reduce it. The authors explored gender budgeting as a critical tool.

The proposed method of ranking countries involves the implementation of public administration decisions. In particular: the detection of gender gaps; distribution of public finances according to gender differences; based on A/B testing to identify gender-sensitive budgets that need the most adjustment; conducting a qualitative assessment of the need for specific measures by comparing socio-economic development indicators.

Consequently, governments should adopt gender budgeting approaches that systematically include women's organisations and civil society to ensure proper control and fully assess the impact of economic policies on women and girls. They should support the training of organisations and women in this area and improve the collection of relevant statistics.

The systematic introduction of gender budgeting can contribute to improving the quality of public and local finance management; improving economic efficiency and effectiveness; improving the allocation of financial resources; promoting effective management and quality of services; encouraging the achievement of goals of gender equality and human development; monitoring achieving political purposes, in particular ensuring gender equality; increase transparency, accountability and public participation in planning and budget implementation. The gender budget contributes to improving the quality of services for the population because there are clear guidelines for the specific consumer; increasing the pace of economic development and reducing poverty; efficient use of resources; allows taking attention to a broader range of issues, the solution of which will create equal opportunities for all members of the community and ensure sustainable development. This approach makes the budget efficient, fair and transparent.

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The sustainability of indigenous lands in Amapá state

A sustentabilidade das terras indígenas no estado do Amapá

Alcineia Miranda Campos [1]

Francisco Gean Freitas do Nascimento [2]

Helenilza Ferreira Albuquerque Cunha [3]

[1] Master's Degree in Tropical Biodiversity, Programa de Pós-Graduação em Biodiversidade Tropical, Universidade Federal do Amapá, Macapá, Brazil
E-mail: engflorestal.campos@gmail.com

[2] Specialist in Production Engineering, Information Technology Analyst, Universidade do Estado do Amapá, Macapá, Brazil
E-mail: francisco.nascimento@ueap.edu.br

[3] PhD in Environmental Engineering Sciences, Full Professor, Departamento de Meio Ambiente e Desenvolvimento, Universidade Federal do Amapá, Macapá, Brazil
E-mail: helenilzacunha@gmail.com

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ABSTRACT

We herein assess population growth in indigenous lands (ILs) Wajãpi, Uaçá, Galibi and Juminã in Amapá State-Brazil, which has influenced deforestation increase. We assumed the hypothesis of no association between demographic density and deforestation because population density in these areas is low. We used population growth, deaths, and deforestation data by considering a historical series (2002-2018). Demographic data have shown that Uaçá and Wajãpi ILs recorded the highest population growth. The highest demographic density was observed for Galibi ILs and the lowest one for Wajãpi ILs. The highest deforestation was observed for Uaçá ILs and the lowest one for Juminã ILs. Therefore, indigenous lands in Amapá State have an essential role in forest conservation.

Keywords: Indigenous populations. Population growth. Population density.

RESUMO

Avaliamos se o crescimento populacional nas terras indígenas (TIs) Wajãpi, Uaçá, Galibi e Juminã do estado do Amapá/Brasil influenciou o aumento do desmatamento. Nossa hipótese é que não há relação entre densidade demográfica e desmatamento, pois a densidade populacional nessas áreas é baixa. Utilizamos o crescimento populacional, o número de óbitos e os dados de desmatamento

levando em conta uma série histórica (2002-2018). Dados demográficos mostraram que as TIs Uaçá e Wajãpi registraram o maior crescimento populacional. A maior densidade demográfica foi observada na TI Galibi e a mais baixa na TI Wajãpi. O maior desmatamento ocorreu na TI Uaçá e o menor ocorreu na TI Juminã. As estimativas de desmatamento até 2028 confirmaram que a TI Uaçá terá baixo desmatamento. Portanto, as terras indígenas no estado do Amapá têm relevante papel para a conservação da floresta.

Palavras-chave: *Populações indígenas. Crescimento populacional. Densidade demográfica.*

1 INTRODUCTION

The uncontrolled anthropic interference in the environment has led to vast and irreversible biodiversity losses worldwide (CEBALLOS *et al*., 2017). For example, estimates have shown that only 32% of forests globally are primary, and 35% were turned into agricultural land (KORMOS *et al*., 2017). Therefore, one of the main anthropic interferences in the biosphere is caused by deforestation (RUDDIMAN, 2013).

Deforestation in the Amazonian rainforest, which is the most extensive tropical forest in the world, accounts for considerable biodiversity losses (GIBSON *et al*., 2011; GROSS, 2016) because several fauna and flora species that remain non-catalogued are lost every time a forest coverage is removed, be it due to cutting or burns, for agricultural or road construction purposes. Thus, the anthropic pressure resulting from population growth and demographic density has been preceding deforestation and, consequently, the pressure over non-renewable natural resources - such a process changes the balance and dynamics of natural processes (OLIVEIRA *et al*., 2015). Demographic factors are some of the main deforestation causes in tropical regions (GEIST; LAMBIM, 2001). They are not significantly different from those observed in the temperate areas some centuries ago (ARRAES *et al*., 2012). Tropical deforestation has been growing since the 1970s; therefore, it has become a world concern (ARAGÃO *et al*., 2014; RUDEL, 2007).

The Brazilian Legal Amazon has been suffering from substantial occupation pressure, as well as from agricultural expansion and climate changes (LOVEJOY; NOBRE, 2018) that, altogether, reduce soil fertility, cause erosion, change local and global water regimes and increase greenhouse gas emissions (FEARNSIDE, 2005; LAURANCE *et al*., 2004; NOBRE *et al*., 1991). Consequently, this process threatens biodiversity conservation (MALHI *et al*., 2008). Furthermore, climatic changes caused by uncontrolled deforestation can increase temperatures and become an irreversible hazard to the planet (ARAGÃO *et al*., 2018; FEARNSIDE, 2006; HEGERL *et al*., 2006).

There was a significant drop in the deforestation rates between 2004 and 2012 in the herein assessed region due to the public policies adopted; however, from May 2013 onwards, deforestation returned to considerable growth levels. In 2016, approximately 8,000 km^2 (19%) of the forest was destroyed, and in 2018 this number was close to 800,000 km^2. Pará state stood out for the highest deforestation rate in the Northern Region (34% of the total), based on the increase in deforestation rates in the Legal Amazon (PRODES, 2018).

The reasons presented to justify the decline in deforestation in Brazil between 2004 (it reached 27.7 thousand km^2) and 2012 (it dropped to 4.4 thousand km^2) were: the public policies adopted at that time, the actions taken by civil society and the economic policies adopted by the Brazilian Government (ARAGÃO *et al*., 2018), such as the implementation of the Action Plan for the Prevention and Control of Deforestation in the Amazon (APPCDAm), back in 2004, as well as the creation and maintenance of protected areas (PAs).

This scenario has changed in the last few years, and deforestation started growing again, mainly after the approval of the new Forest Code (law 12.651, 2012) (ASSUNÇÃO *et al*., 2012), which provides

flexible rules in comparison to the law enacted in 1965. This change represented a challenge for the national government (KROGER, 2017).

Brazil faces balancing agricultural production growth and environmental protection sites (GIL *et al*., 2015). The ability to meet the food, fuel and energy markets' demands for the decades to come has been a reason of concern in the country since it must take into account the need for such an agriculture and livestock production expansion without threatening environmental protection sites since Brazil is one of the largest world producers of these commodities (NEPSTAD *et al*., 2009).

The creation of PAs was one of the most effective policies to ensure biodiversity conservation worldwide (STOLTON; DUDLEY, 2010; WATSON *et al*., 2014); it became an essential strategy to reduce deforestation. As a result, their surface in the Brazilian Amazon has doubled between 2000 and 2009. Back in 2019, it reached 2,000,000 km^2, which forced the deforestation rates down (PEREIRA *et al*., 2019).

Indigenous lands (ILs) are among the PAs, mainly contributing to reducing deforestation. However, the inhibiting effect exerted by ILs on Amazonian deforestation can also be observed if one considers the deforested area in the region. Up to 2014, almost 20% of the forest area in the Brazilian Amazon was deforested, but it was lower than 2% in ILs, a fact that proves their reduction effect on deforestation (CRISOSTOMO *et al*., 2015).

Indigenous peoples have been the guardians of the most extensive tropical forest on the planet for thousands of years (RICKETTS *et al*., 2010; WALKER *et al*., 2020). They have occupied the Amazon based on environmental management practices and strategies (WATLING *et al*., 2017), such as the domestication of plants and animals (LEVIS *et al*., 2017) and soil changes through controlled fire (SCHMIDT *et al*., 2014). Such practices led to improvements in the local landscape and better heterogeneity between forest species, mainly among the rare ones. They also avoided the accumulation of combustible material (leaves, branches and the trunks of dead trees) that could cause a natural wildfire. As a result, these peoples have been making significant contributions to the Amazonian biodiversity from the pre-Colombian era to present times (FRANCO-MORAES *et al*., 2019; POSEY, 1985).

These people also set relationships with the environment beyond the simple extraction of resources (RAMOS, 1995). Indians protect biodiversity, the right to land and subsistence by valuing their traditional ways of life (MARETTI *et al*., 2014). Therefore, they have played a fundamental role in biodiversity formation in South America. Several plant species, such as Brazil-nut, cocoa and cassava, and many animal species, have emerged as a product from such an interaction; they formed forest management based on traditional modes. This process accounted for the biological conservation and diversity of ecosystems (BATISTA *et al*., 2020). Land use practices are different depending on the traditional knowledge of these peoples, which is combined with their traditional ways of life and the modern perspective about sustainable land use (STEVENS *et al*., 2014; TAULI-CORPUZ *et al*., 2018).

Based on estimates, these people encompass 1.7 million individuals who are distributed into 375 indigenous groups living in 3,344 indigenous territories countrywide and the biogeographic limits of the Amazon. These ILs, in Brazil cover 721 sites and occupy 13.8% of the national territory (1,174,263 km^2) (ISA, 2019). Most of them are in the Legal Amazon, which holds 115.3 million hectares (Mha) distributed into 414 traditionally occupied ILs (FANY *et al*., 2015). Thus, ILs represent approximately 23% of the Amazonian Territory; they are in well-conserved forests within a mosaic of PAs covering the Amazonian territory (COSTA, 2019).

Amapá state, Northern Brazil, stands out for its biodiversity; it holds a diversified combination of ecosystems (MUSTIN *et al*., 2017). Furthermore, it is the most protected state in Brazil, given its

historical isolation and several PAs in it (PERES *et al*., 2014). The federal and state governments were quite active in defining the PAs and the indigenous lands that covered 72% of the state (CUNHA *et al*., 2019). As a result, Amapá counts on 19 PAs, 12 of them are managed by the Federal government; 5 by the State government and 2 are managed by local governments (BRITO, 2008) – the state also holds 5 indigenous lands, namely: Wajãpi, Uaçá, Galibi, Juminã and Tumucumaque Mountains National Park.

ILs in Amapá state account for 9,635 individuals spread into indigenous villages; they also conserve more than 11,256.71 km^2 of forests. These peoples are ethnically different and have different costumes, garments, economic models and agriculture; however, they are similar in the struggle for their rights and sustainability concerns. Furthermore, these people got together to protect their territory, and all ILs were demarked back in the 1970s and approved in the 1990s (GALLOIS; GRUPIONI, 2003). Accordingly, the present study aimed to test the hypothesis that the indigenous population has grown but that it did not lead to deforestation increase in their lands since the sustainability of these sites is ensured by how these peoples manage them.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The study was carried out in four ILs in Amapá state (Figure 1), Northern Brazil. The following ethnicities live in them: Wajãpi, Uaçá, Galibi and Juminã.

Wajãpi IL (Figure 1a) is located in Pedra Branca do Amapari and Laranjal do Jari counties, Midwestern Amapá state. It holds approximately 1,500 people within a demarked area of about 607,000 ha (APINA; AWATAC; IEPÉ, 2017). Wajãpi IL borders with Pas in Tumucumaque Mountains National Park, Iratapuru River Sustainable Development Reserve, Amapá State Forest, Beija-Flor Brilho de Fogo Extractivist Reserve and Perimetral Norte settlement Project at BR-210 (MORENO *et al*., 2018).

Uaçá, Galibi and Juminã Ils are located in Northern Amapá state (Figure 1b); they are known as the "Low Oiapoque Indigenous Peoples" (SANTOS; SANTOS, 2017). The population in these three Ils accounts for 8,109 individuals: 7,659 in Uaçá, 164 in Galibi and 286 in Juminã – divided into more than 50 indigenous villages (DSEI, 2019). These Ils are demarked within a huge continuous area covering 518,654 ha: Uaçá – 470,164 ha, Galibi – 6,889 ha and Juminã – 41,601 ha (SANTOS; SANTOS, 2017); they are crossed to the West by BR-156. Juminã and Galibi Ils border with the French Guiana to the North of Amapá state. Uaçá IL borders with Cabo Orange National Park to its West (TASSINARI, 2003; VIDAL, 2013).

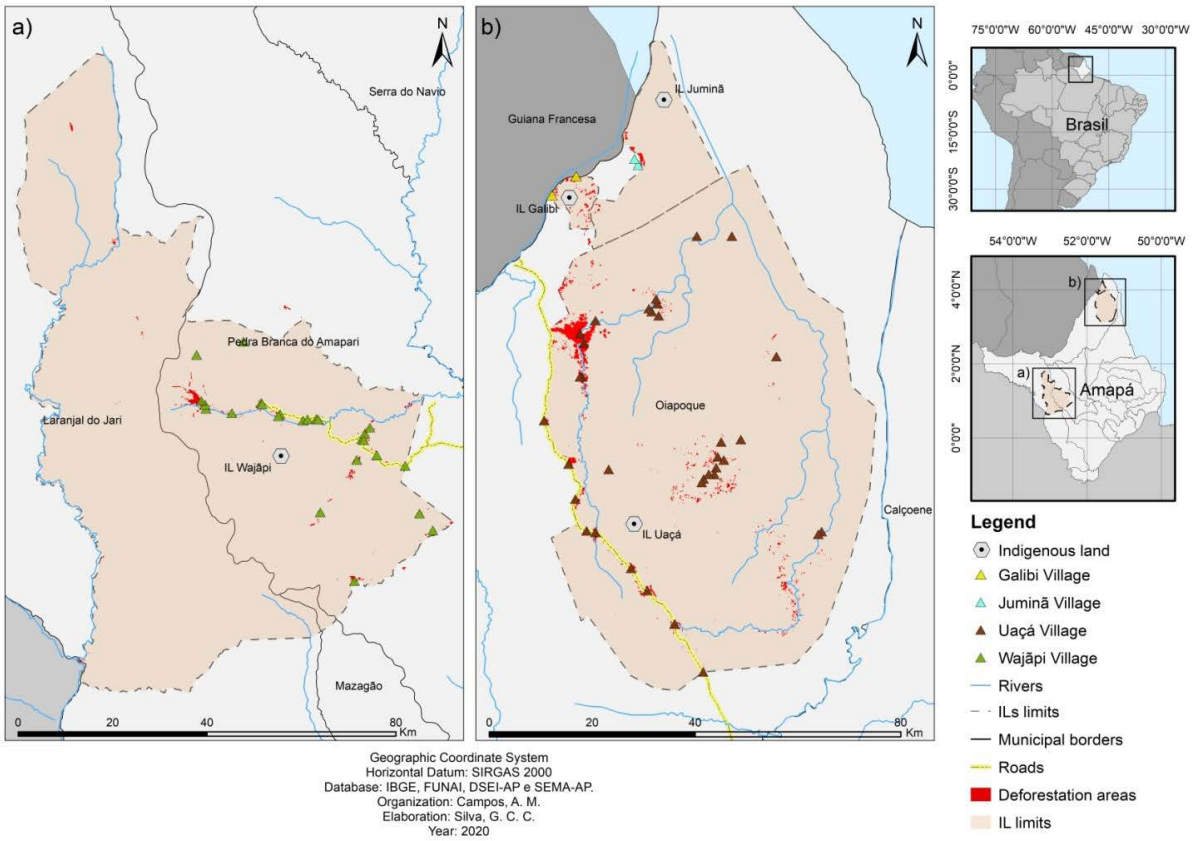

Figure 1 | Ils in Amapá state: a) Wajãpi and b) Ils Oiapoque, Uaçá, Galibi and Juminã.

Source: Authors.

2.2 DATA COLLECTION

The Ethics Committee approved the research of Unifap (CAEE 10800919.0.0000.0003). It used secondary data on these Ils: population growth (made available by the Special Indigenous Sanitary District of Amapá/DSEI-AP), birth and death data, and deforestation data (made available by the Environment State Secretariat/Sema-AP). Data regard a 2002-2018 historical series.

Deforestation data were collected through remote sensing by the LANDSAT 5 satellite – data were made available by the National Institute of Spatial Research (INPE, 2013). In addition, shapes used to quantify deforestation areas were made public by Sema. However, although the quantification of Amazonian deforestation is carried out by Inpe, through the Amazonian Deforestation Estimation Project, also known as Prodes, Amapá state is not satisfactorily assessed due to its high nebulosity throughout the year (SEMA-AP, 2014) – this climatic feature made it impossible getting good-quality satellite images. Therefore, the analysis of the images was carried out in November when skies were clearer in the Northern Region.

Sema works with original image parameters, 30x30m pixels since they allow mapping smaller areas: approximately 0.1 ha. We have adopted deforestation concepts, such as that of clear-cutting, which is used by Inpe/Prodes and is featured by the total removal of the forest cover within a short period: larger than 6.25 ha of cutting in primary forest (INPE, 2013). Often, a clear-cutting is carried out to allow the planting of another culture, be it agricultural or forest crop; the so-called “conversion” (FAO, 1989; FLOR, 1985).

2.3 STATISTICAL ANALYSIS

Population growth and Ils' deforestation data in Amapá state were organised in Microsoft Excel 2007® spreadsheets and, subsequently, assessed for data normality based on the Shapiro-Wilk method carried out in Rstudio® application Version 1.0.153. After data normality was found, Pearson's correlation coefficient ® was applied to measure the degree of relationship among variables, which was confirmed through linear regression (r^2) adopted to assess data quadratic residue. The tests were performed in the RStudio® application Version 1.0.153. Thus, the study universe was equivalent to the total of areas recording 100% data reliability degree. Deforestation shapes were analysed in Microsoft Excel 2007® and QGIS 3.10® software.

Data tabulation allowed observing the lack of deforestation data due to technical issues caused by clouds over indigenous lands throughout the year (Sema information). However, the value accumulated from one year to the other, and it is known that the deforested areas were accounted for in the previous year, but that they were not in the following one. Accordingly, the linear interpolation of the missing data was carried out only to estimate and measure demographic density. The linear interpolation method was based on superior and inferior register data. The adopted criterion to find X (empty fields) between a and b values (fields with data) was $\{x \in R \mid a < x < b\}$, by using the line formation law $f(x) = ax + b$ (ARENALES; DAREZZO, 2008; RIBEIRO, 2014).

Equation 1 was used to find the demographic density, wherein d is density, A is the total demarked area in Km², and n is the total number of inhabitants per year.

$$d = \frac{A}{n} hab/Km^2 \qquad (1)$$

Deforestation value was calculated through the linear function adjusted by the minimum quadratic method, based on population growth and deforestation data, by following criteria in the following equations. It was done to model ILs' deforestation by 2028.

Line formation law $f(x) = ax + b$ generated from tabulated and interpolated data; wherein the **a** value is found through equation 2a, and the **b** value is calculated through equation 2b:

$$a = \frac{\left(n.\sum xy\right) - \left(\sum x.\sum y\right)}{\left(n.\sum x^2\right) - \left(\sum x\right)^2} \qquad (2a)$$

$$b = \frac{\left(\sum x.\sum xy\right) - \left(\sum y.\sum x^2\right)}{\left(\sum x\right)^2 - \left(n.\sum x^2\right)} \qquad (2b)$$

The linear regression analysis of variables 'population growth' and 'deforestation' was not carried out due to the lack of deforestation data of ILs' Galibi and Juminã, at some periods. The missing data were not interpolated for greater reliability purposes. Instead, the analysis of the variables was applied to Uaçá and Wajãpi ILs, which presented lesser missing data.

3 RESULTS

3.1 DEMOGRAPHY

The indigenous population in Amapá state increased by more than 50% from 2002 to 2018, considering the number of deaths within the same period. Uaçá IL doubled its population by more than 4,000 inhabitants (56%), despite the high annual average of 15 deaths. Juminã IL recorded population growth of 40% and a mean annual average of 1 death. Galibi IL showed the lowest population growth (23%) due to its mean annual average of 2 deaths. In contrast, Wajãpi IL recorded a population growth of 57% - it was also the second IL recording the highest average of annual deaths (6/year, on average) (Figure 2).

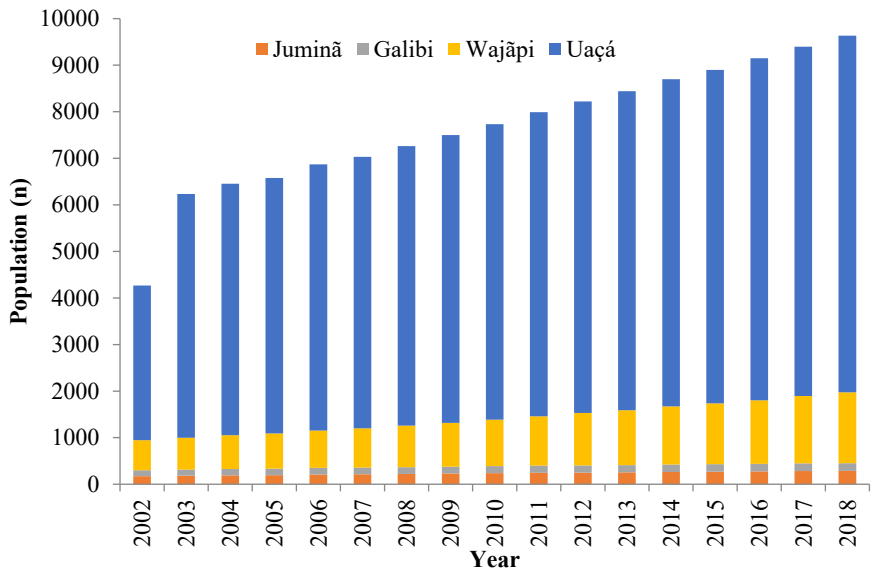

Figure 2 | Annual comparison of population growth in ILs in Amapá state.

Source: Authors.

Demographic density (Table 1) in the ILs was low. The highest mean demographic density was 2.1 inhab/km2, which was recorded for Galibi, IL. This village was followed by Uaçá (1.51 inhab/km2), Juminã (0.56 inhab/km2) and Wajãpi (0.17 inhab/km2). Wajãpi IL recorded the lowest demographic density in 2002 (0.11 inhab/km2) and the highest in 2018 (0.25 inhab/km2). The highest density was recorded for Galibi IL (2.38 inhab/km2) in 2018. Considering data from the 2010 IBGE census, demographic density in Oiapoque County was 0.91 inhab/km2, in Laranjal do Jari County, it was 1.29 inhab/km2, and in Pedra Branca do Amapari, it was 1.29 inhab/km2. Thus, in this same year, Galibi IL presented data higher than that recorded for Oiapoque density. In contrast, Wajãpi IL showed data lower than the density recorded for the Laranjal do Jari and Pedra Branca do Amapari counties.

Table 1 | Comparison of annual demographic density of ILs in Amapá state.

	(inhab/Km^2)			
Year	*Juminã*	*Galibi*	*Wajãpi*	*Uaçá*
2002	0.42	1.83	0.11	0.71
2003	0.44	1.92	0.11	1.11
2004	0.46	1.97	0.12	1.15
2005	0.47	2.02	0.13	1.17
2006	0.50	2.06	0.13	1.22
2007	0.52	2.08	0.14	1.24
2008	0.53	2.12	0.15	1.28
2009	0.55	2.13	0.16	1.31
2010	0.58	2.18	0.16	1.35
2011	0.59	2.24	0.18	1.39
2012	0.60	2.25	0.19	1.42
2013	0.61	2.28	0.19	1.46
2014	0.63	2.34	0.21	1.49
2015	0.65	2.34	0.22	1.52
2016	0.66	2.37	0.22	1.56
2017	0.68	2.40	0.24	1.60
2018	0.69	2.38	0.25	1.63

Data on blue were interpolated.

Source: Authors.

3.2 DEFORESTATION

Deforestation accumulated up to 2002 in Wajãpi IL reached 482 ha (Figure 3a). Uaçá IL presented the highest accumulated deforestation (2,793 ha), which was followed by Galibi IL (351 ha), and by Juminã IL, which recorded the lowest accumulated deforestation (120 ha) (Figure 3b).

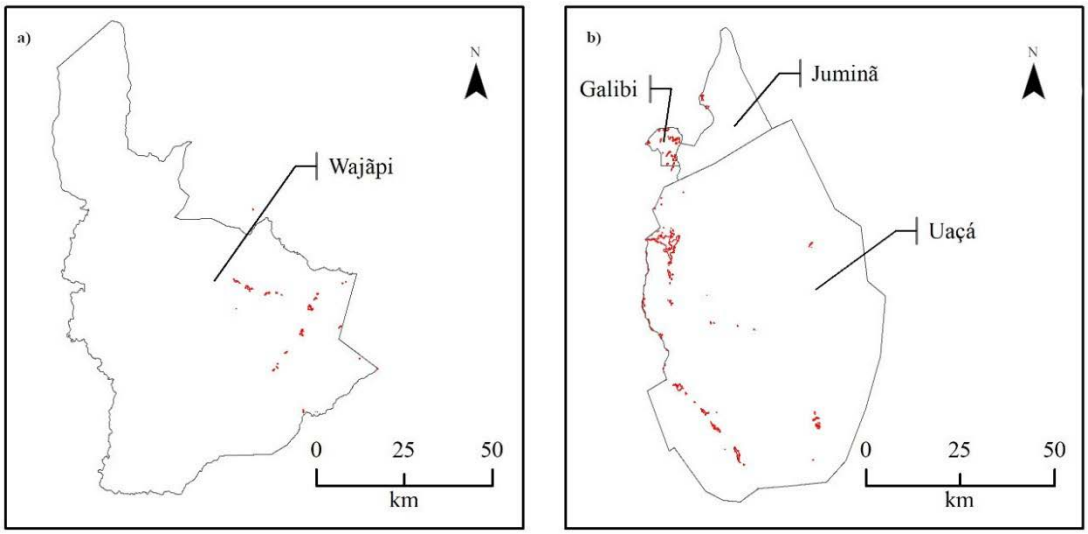

Figure 3 | Accumulated deforestation up to 2002 in ILs: a) Wajãpi IL, b) Oiapoque ILs.

Source: Authors.

Accumulated deforestation up to 2018 at Wajãpi IL (Figure 4a) reached 2,312 ha; it was 7,883 ha in Uaçá, 560 ha in Galibi and 363 ha in Juminã (Figure 4b).

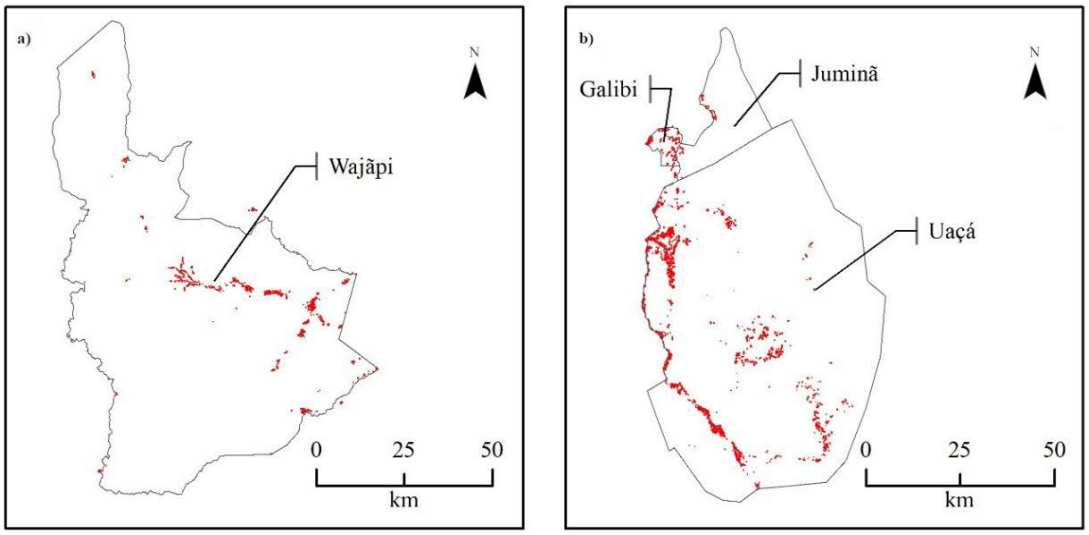

Figure 4 | Accumulated deforestation up to 2002 in ILs: a) Wajãpi IL, b) Oiapoque ILs.

Source: Authors.

In 2002, the four ILs recorded land use peaks (Figure 5). Deforestation ranged from low to high values at Wajãpi IL: 474 ha (2002), 39 ha (2005), 537 ha (2012), 154 ha (2015). Uaçá recorded high values of it: 615 ha (2008), 1,067 ha (2012), 956 ha (2018). On the other hand, the numbers recorded for Galibi IL have decreased: 104 ha (2002), 89 ha (2004), 19 ha (2014), 22 ha (2018). Finally, Juminã, despite the strong correlation among variables, presented low values for land use: 40 ha (2002), 12 ha (2006); but there was an increase by 148 ha in 2018.

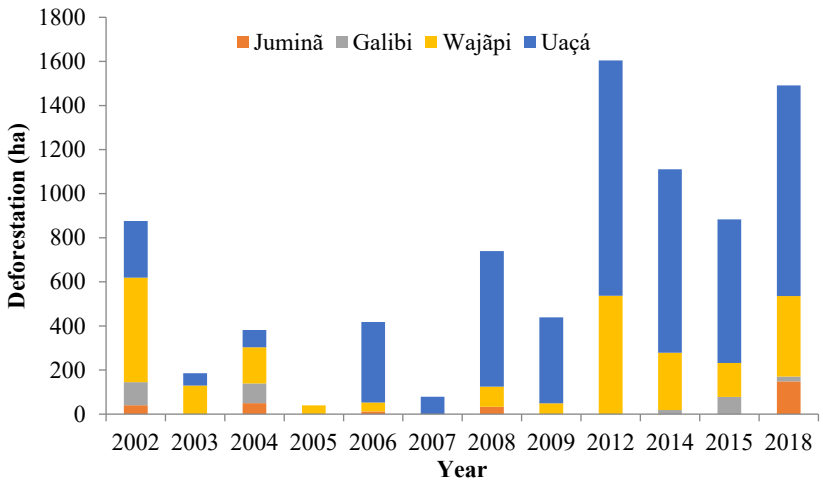

Figure 5 | Comparison of deforestation in ha of ILs in Amapá State – from 2002 to 2018.

Source: Authors.

Mean deforestation in the ILs ranged from 16.69 ha (Juminã) to 314.54 ha (Uaçá). However, within 18 years, Galibi used approximately 10% of its total territory (6,889 ha), and Wajãpi did not reach 1% (607,017 ha) of it, even if one considers the accumulated deforestation in 1999 and the interpolated data.

Although Uaçá is the second-largest IL in territorial extension (470.16 ha), it was also the first one in population growth, approximately 7,000 inhabitants, and the first one in deforestation. Uaçá used 2% of its total land up to 2018 (accumulated and interpolated deforestation).

Based on the statistical Shapiro-Wilk test, Wajãpi recorded P-value = 0.23 for variable "population" and P = 0.06 for "deforestation", both at P > 0.05; this finding proved data normality. Based on this IL, the linear regression pointed out that less than 1% of the population (r2 = 0.096) explains the observed deforestation. This result justifies the absence of other analyses and estimates for population and deforestation by 2028. Uaçá presented P = 0.44 for population and P = 0.33 for deforestation, both at P > 0.05. Uaçá data were also normal, and their linear regression showed that approximately 50% (r2 = 0.492) of variable 'population' explains the deforestation process in this IL.

In 2002, Uaçá recorded deforestation of 257 ha for a population of 3,332 people. In 2003 and 2007, there was a significant reduction in land use, even if one considers the population increase. There was deforestation peak in 2008 (625 ha) and population increase by more than 6,000 people in this same year. There was a reduction of approximately 50% in deforestation in 2009, compared to the previous year. Although there was also a reduction in the deforestation records – the population kept on growing. From 2010 on, it was possible observing deforestation data fluctuation, high peaks in 2012 (1,070 ha) and population growth by 6,689 inhabitants. After 2012, the most considerable deforestation was recorded in 2018; it corresponded to 956 ha and 7,659 inhabitants (Figure 6).

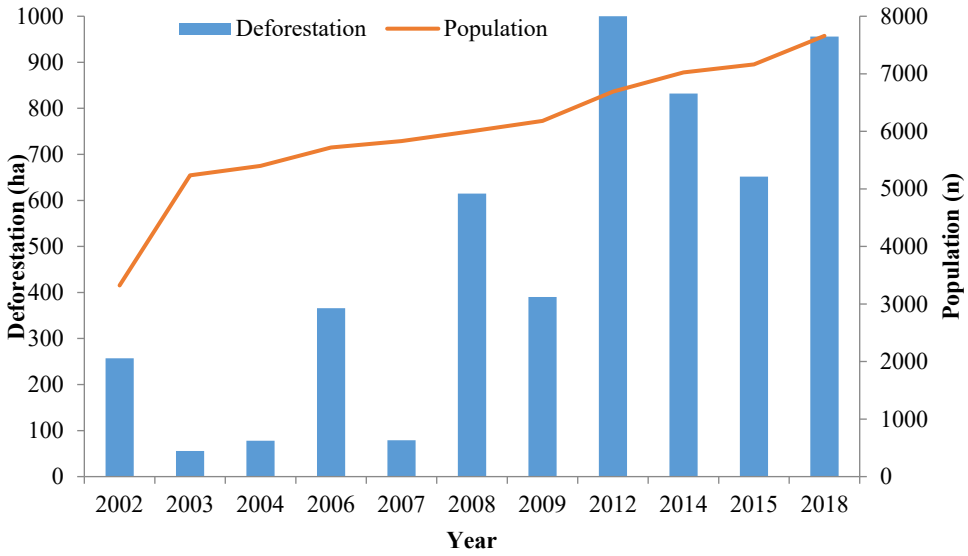

Figure 6 | Comparison between population number and annual deforestation in Uaçá IL.
Source: Elaboration of the authors.

3.3 DEFORESTATION ESTIMATES

Due to the lack of data, the modelling analysis adopted to estimate population and deforestation by 2028 (10 years) did not apply to Galibi and Juminã ILs. Furthermore, it was impossible to model Wajãpi IL because Pearson's analyses pointed towards weak association (r = 0.31) among variables, which was proven by the linear regression.

Thus, modelling was only carried out for Uaçá IL; some missing deforestation data were interpolated. According to the Pearson's test, Uaçá presented a strong correlation (0.74) between variables. The linear regression analysis confirmed it: 0.55% of the assessed variables (population growth and deforestation)

explained a strong correlation between variables. Thus, the deforestation and population growth increase were continuous in this IL (Figure 7).

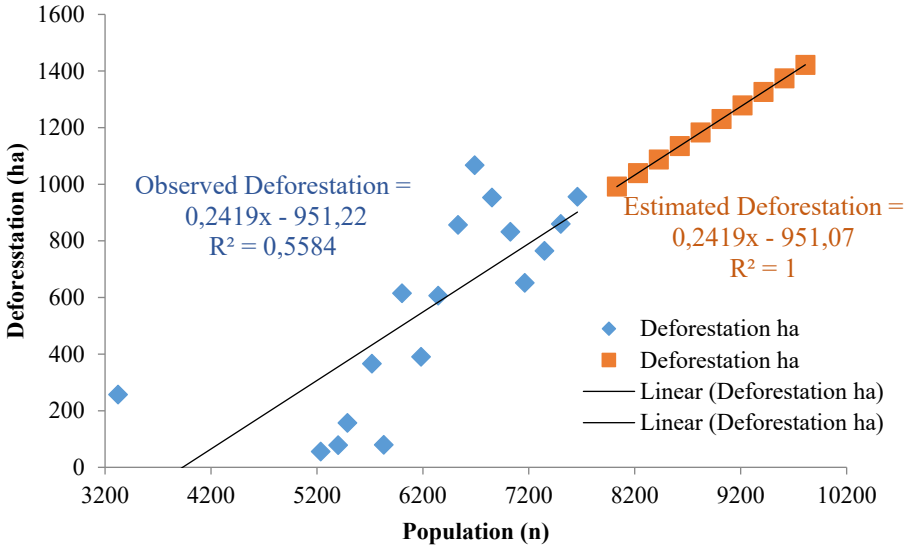

Figure 7 | Population and deforestation growth estimates up to 2028 in Uaçá IL.
Source: Elaboration of the authors.

The population will increase by approximately 1,800 inhabitants by 2028, and it is more than the increase recorded in 2018; deforestation will reach 1,421.97 ha, by the same year. There will be a difference of almost 466.09 ha within 10 years. There was exponential growth both in population and deforestation. Uaçá IL population will use 4.6% of the total of its 470 ha, by 2028, despite the wide use of land for production focused on subsistence and the local cassava flour supply.

4 DISCUSSION

4.1 DEMOGRAPHY

It was possible observing continuous population growth in Wajãpi IL based on the association among demographic data, population growth, number of deaths and demographic density. However, the Wajãpi people were once seen as more numerous; a drop in the number of inhabitants took place during a malaria outbreak caused by contact with non-indigenous individuals (APINA; AWATAC; IEPÉ, 2017).

Demographic density in this IL did not reach 1 inhab/km², even if one considers the years accounting for the highest deforestation rates. This finding is explained by the size of its territory (607,000 ha) and its population of approximately 1,500 inhabitants. Wajãpi IL recorded the mean birth of 52 people/year and low land use since it only used 0.63% of its territory – the rest was conserved.

Accordingly, one can observe the importance of keeping big PAs, where indigenous peoples play the role of conserving ecosystems for future generations (GARNETT *et al.*, 2018) and preserving their culture and traditional knowledge.

The association between variables "population growth" and "deforestation" in Wajãpi IL was weak. It did not influence land use; in other words, the deforestation trend concerning the population heads

towards stability. This is because wajãpi people live in isolation, surrounded by PAs; they have traditional customs. The reduced soil use for agriculture, crop opening, and house construction in this IL are linked to these people's traditions.

Crop use-time and its management are other relevant factors for land use reduction. Wajãpi people have used the same crop for approximately 20 years. After its use, they leave the land to rest and open a new crop by the old one. They allow a line of primary forest between crops to speed up natural recovery (APINA; AWATAC; IEPÉ, 2017). It is essential to highlight those secondary forests play a crucial role in conserving biodiversity and providing ecosystem services, such as carbon fixation (POORTER *et al*., 2016).

Indigenous peoples' crops in Amapá state are family farms. Thus, they demand specific sizes (approximately 1 to 3 ha, depending on the interest and need of each family and resource availability). According to Silveira (2015), the choice for crop-size limits is related to nature's elements such as rivers, waterfalls, hunt and fruit collection availability, seeds and materials for craftsmanship and house constructions.

The indigenous peoples, for a long now, acknowledge the importance of conserving and properly managing their land, not just because they provide their material needs, but because they reinforce or redefine their traditional commitment to the land (GARNETT *et al*., 2018).

Among all ILs, Uaçá was the one that has grown the most, despite its high annual average of deaths compared to the other ILs. Based on information by DSEI-AP, parasitic diseases account for the most significant number of fatalities in Amapá's ILs.

Although Uaçá had presented the highest deforestation and population growth rates, its demographic density did not reach 2 inhab/km^2. Land use up to 2018 was low, even after using land for agriculture. Thus, the strong dependence on natural resources, its organisational structure relation, and its management systems – developed through generations – are its vital conservation elements associated with its areas (DIEGUES *et al*., 2000).

There was a strong association between variables "population growth", and "deforestation" in Uaçá IL and this finding has statistically proven the trend of growth between them. These people extensively use their land because they grow cassava (at a large scale) to be traded in Oiapoque County and for subsistence. However, despite the cultivation for local trading, deforestation was low compared to other ILs in the Northern Region, such as in Puyanawa IL, in Alto Juruá (AC), which has 16 flour houses for local supply. The Puyanawa people are known as great flour producers: approximately 500 tons/year, and for their land use applied to other cultivars of fruits that are part of their diet, such as *açaí* (FOWLER, 2020).

Even when the indigenous culture faces changes due to the adoption of non-indigenous market society values, these peoples keep their sustainable cultivation practices. Changes in cultivation in tropical forests often concern cleaning practices to the plantation of food and non-wooden products (used to house constructions and in craftsmanship, which is other income sources). The exhaustion of soil nutrients or infestation with agricultural pests are the reason to let the land rest so that the forest can recover and start to grow again (BECKERMAN, 1987).

Galibi IL recorded the lowest population growth among Oiapoque's ILs. The trend in this IL pointed towards population stability, despite its low mean annual mortality rate. The mean annual rate of births from 2002 to 2018 was 1.3 people. The death cases were recorded for children younger than 1 year and people over 50 years old – there are several elderlies in the age group close to 100 years (DSEI, 2019). These data have confirmed that population growth in Galibi IL has decreased, reducing land use. Galibi IL recorded the highest demographic density (close to 3 inhab/km^2). It is necessary to consider that, despite its high density, it has the smallest territory (6,889 ha), but it did not influence deforestation.

Juminã IL recorded low population growth and low mean annual deaths. Therefore, its demographic density and deforestation rates are low, except in the years when it was possible to observe higher population growth and deforestation. This IL produces cassava flour and has potato, sweet potato and green vegetable crops, and fruit trees for subsistence, but they do not occupy large land extensions. Thus, population growth did not have a negative influence on deforestation increase.

The demographic density of indigenous peoples in Amapá state is lower than that recorded for other ILs countrywide. For example, the demographic density of indigenous peoples at Dourado Indigenous Reservation (MS) was the highest among indigenous peoples in Brazil up to 2013 (300 inhab/km^2) (BARBOSA *et al*., 2016). However, most ILs in Brazil accounts for low demographic density, such as the case of Rio Xingu Terra do Meio Extractivitst Reserve (PA), with its 0.81 inhab/km^2, which houses riverside populations and indigenous peoples (Arara Kuruaya, Parakanã, Xikrin and Xipaya) (ISA, 2020). In 2008, demographic density at Raposa Serra do Sol IL (RR) was 1.1 inhab/km^2 and an approximate population of 19 thousand inhabitants (Macuxi, Wapichana, Taurepang, Patamona and Ingarikó peoples) within 1,747,464 hectares (USP, 2020).

4.2 DEFORESTATION

All ILs had deforestation peaks from 2002 to 2018, but population growth did not influence it. Nevertheless, there were moments when it was possible observing high deforestation in all ILs. It is worth highlighting that ILs close to the roads can face deforestation threats. There is a strong association between deforested sites and the influence of roads within the deforestation process (NEVES *et al*., 2021).

Thus, Uaçá IL recorded a higher deforestation rate than the other ILs, and it can be justified by its intense land use for cassava crops, for flour production and trading in the local market.

The environmental strategy to form secondary forest adopted by the Wajãpi people is also adopted by the Kayapó people (Xingu River, Brazil). Forest spots between agricultural cultures are called “apetês”; they ensure the formation of secondary forests and work as barriers at times of war, as parapets and defence lines for indigenous villages; at times of peace, they are used as a place for resting, for spending the warmest times of the day (POSEY, 1985).

Secondary succession regards the replacement of organisms by another type of organisms from an environment that has been disturbed by hurricanes, drought events, landslides – due to strong wind –, cutting agricultural practice, burns or intensive agriculture (ERICKSON; BALÉE, 2006). The influence of human management also changes the Amazonian Biodiversity.

The Amazonian Biodiversity was influenced by human management, for example, when it comes to differences in the relative abundance of species between the ancestral and old forests, which are not related to soil conditions, but to previous human management (FRANCO-MORAES *et al*., 2019). The indigenous peoples in Amapá state manage their land by targeting their future and the future of the forest. The traditional knowledge of these peoples covers management practices that limit low-intensity environmental disturbances to ensure ecosystems’ stability and resilience (BEGOSSI *et al*., 2000). Thus, it was proven that old indigenous populations had a hybrid lifestyle, including fishing, hunting, extracting, picking up fruits and forest management. This process allowed their non-full (only partial) dependence on agriculture (ROWLEY-CONWY; LAYTON, 2011). These populations managed the forest and opened the room to create agroforest systems by enriching them with valuable species and suppressing the undesired ones (ERICKSON; BALÉE, 2006).

As time went by, it was possible observing that the trend of indigenous peoples to protect their forests against deforestation got lost, as these groups started to adopt non-indigenous costs – it also increased their demographic density (TERBORGH; VAN SHAIK, 2002). Nepstad *et al*. (2006) tested this hypothesis

and assessed the "response from deforestation inhibition by indigenous reservations since their first contact with non-indigenous groups and from demographic density". Their study was carried out based on the analysis of satellite images; they concluded that the tested comparisons did not lead to any significant association between variables. Thus, they have confirmed that indigenous reservations inhibit deforestation, their land use relationship with the forest disturbances is weak, but it is relatively high in inhabited and invaded areas.

4.3 DEFORESTATION ESTIMATES

A research about deforestation estimate for Amapá state by 2030 has shown that although the state shows an isolated geographic profile in comparison to the rest of the country – a fact that contributes to the high native vegetation cover preservation degree –, deforestation has been growing in the last decades (LESS *et al.*, 2018).

Unlike the results recorded by Less *et al*. (2018), estimates about the increase in deforestation and population growth in Uaçá IL were low if one considers the 10-year projection by 2028. The estimated modelling to 2028 recorded a low population growth increase and approximately 50% more deforestation than that accumulated until 2018. However, if one considers the size of the land and how it is used, these processes will not negatively influence forest coverage. According to Fearnside *et al*. (2009), deforestation inside ILs is not considered since land use there has low impact and focuses on subsistence.

The social organisation model is based on low population density and high mobility in the territory as a whole, such as the case of indigenous peoples, in addition to management practices based on traditional knowledge and the conscious use of natural resources (fishing, hunting, wooden and non-wooden products), can ensure the maintenance of traditional peoples, as well as biodiversity and forest conservations (BEGOSSI *et al*., 2000; SMITH; WISHNIE, 2000).

Based on the results, it is possible to state that territory size is essential in ensuring forest conservation and biodiversity because it can influence PA's effectiveness in stopping deforestation. The smallest PAs present higher deforestation than those holding large blocks of forests, more than 10,000 km^2. Even so, the smaller areas that are more subjected to anthropic pressure manage to contain deforestation. The internal percentage of deforestation is lower than that outside its external limits (location close to 10 km) (VITEL; FEARNSIDE; GRAÇA, 2009).

5 CONCLUSION

We have confirmed the hypothesis that there is no association between demographic density in ILs and deforestation in Amapá state since density in these areas is relatively low. Their sustainability is ensured by the way Indians use the land, mainly for subsistence cultures. Indigenous peoples conserve their land and are concerned with sustainability; they use land based on traditional knowledge. Such knowledge on preserving and protecting the land and fighting for their rights is passed on through generations.

Deforestation in Amapá's ILs was low, and this finding has shown that these areas have a high potential for forest conservation. The herein used variables presented a solid correlation to each other in all ILs, except for Wajãpi, which showed a weak correlation to them; Galibi IL recorded a robust negative correlation to them. This IL deserves closer attention from the scientific community and several governmental spheres since its population is decreasing. We believe that this is not a common factor among indigenous peoples.

The size of the territory is an essential factor for life, culture, and traditional knowledge conservation and the guarantee of forest conservation and biodiversity maintenance. Therefore, understanding the increase in deforestation rates and population growth in ILs is essential to predict the measures

indigenous community leaders and the State government can take to ensure forest conservation and life maintenance among traditional peoples.

Based on the current research, assessing and evaluating the causes of low population growth in the Galibi and Juminã ILs are variables to be considered because, without these people, lands can be at risk of invasion by miners; and illegal timber exploration hunting and fishing. Furthermore, it is vital to reinforce public policies focused on healthcare and education, specific to indigenous peoples. Finally, it is worth highlighting the urgent need of paying attention to Uaçá IL, which recorded high mean annual death rates because of public health issues.

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A sustentabilidade das terras indígenas no estado do Amapá

The sustainability of indigenous lands in Amapá state

Alcineia Miranda Campos [1]

Francisco Gean Freitas do Nascimento [2]

Helenilza Ferreira Albuquerque Cunha [3]

[1] Mestre em Biodiversidade Tropical, Universidade Federal do Amapá, Macapá, AP, Brasil
E-mail: engflorestal.campos@gmail.com

[2] Especialista em Engenharia de Produção, Analista em Tecnologia da Informação, Universidade do Estado do Amapá, Macapá, AP, Brasil
E-mail: francisco.nascimento@ueap.edu.br

[3] Doutora em Ciências da Engenharia Ambiental, Professora Titular do Departamento de Meio Ambiente e Desenvolvimento, Universidade Federal do Amapá, Macapá, AP, Brasil
E-mail: helenilzacunha@gmail.com

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ARTICLE – VARIA

RESUMO

Avaliamos se o crescimento populacional nas terras indígenas (TIs) Wajãpi, Uaçá, Galibi e Juminã do estado do Amapá/Brasil influenciou o aumento do desmatamento. Nossa hipótese é que não há relação entre densidade demográfica e desmatamento, pois a densidade populacional nessas áreas é baixa. Utilizamos o crescimento populacional, o número de óbitos e os dados de desmatamento levando em conta uma série histórica (2002-2018). Dados demográficos mostraram que as TIs Uaçá e Wajãpi registraram o maior crescimento populacional. A maior densidade demográfica foi observada na TI Galibi e a mais baixa na TI Wajãpi. O maior desmatamento ocorreu na TI Uaçá e o menor ocorreu na TI Juminã. As estimativas de desmatamento até 2028 confirmaram que a TI Uaçá terá baixo desmatamento. Portanto, as terras indígenas no estado do Amapá têm relevante papel para a conservação da floresta.

Palavras-chave: Populações indígenas. Crescimento populacional. Densidade demográfica.

ABSTRACT

We herein assess population growth in indigenous lands (ILs) Wajãpi, Uaçá, Galibi and Juminã in Amapá State-Brazil, which has influenced deforestation increase. We assumed the hypothesis of no association between demographic density and deforestation because population density in these areas is low. We used population growth, deaths, and deforestation data by considering a historical series (2002-2018). Demographic data have shown that Uaçá and Wajãpi ILs recorded the highest population growth. The highest demographic density was observed for Galibi ILs and the lowest one for Wajãpi ILs. The highest

deforestation was observed for Uaçá ILs and the lowest one for Juminã ILs. Therefore, indigenous lands in Amapá State have an essential role in forest conservation.

Keywords: *Indigenous populations. Population growth. Population density.*

1 INTRODUÇÃO

A interferência antrópica descontrolada no meio ambiente levou a enormes e irreversíveis perdas na biodiversidade em todo o mundo (CEBALLOS *et al*., 2017). Estimativas mostram que apenas 32% das florestas no mundo são primárias e 35% dessas florestas foram transformadas em terras agrícolas (KORMOS *et al*., 2017). Portanto, uma das principais interferências antrópicas na biosfera é causada pelo desmatamento (RUDDIMAN, 2013).

O desmatamento na Amazônia, que é a maior floresta tropical do mundo, é responsável por perdas consideráveis na biodiversidade (GIBSON *et al*., 2011; GROSS, 2016), pois várias espécies de fauna e flora, ainda não catalogadas, são perdidas cada vez que a cobertura florestal é removida, seja por corte ou queima, para fins agrícolas ou para a abertura de estradas. Assim, a pressão antrópica, resultante do crescimento populacional e da densidade demográfica, vem precedendo o desmatamento e, consequentemente, a pressão sobre os recursos naturais não renováveis, fato que muda o equilíbrio e a dinâmica dos processos naturais (OLIVEIRA *et al*., 2015). Os fatores demográficos são vistos como algumas das principais causas do desmatamento em regiões tropicais (GEIST; LAMBIM, 2001), não sendo expressivamente diferentes daqueles ocorridos em regiões temperadas séculos atrás (ARRAES *et al*., 2012). O desmatamento tropical vem crescendo desde a década de 1970, e tornou-se uma preocupação mundial (ARAGÃO *et al*., 2014; RUDEL, 2007).

A Amazônia Legal brasileira vem sofrendo pressão substancial da ocupação, expansão da agricultura, e mudanças climáticas (LOVEJOY; NOBRE, 2018), causando redução da fertilidade do solo, erosão, mudanças nos regimes hidrológicos locais e globais e emissões de gases de efeito estufa (FEARNSIDE, 2005; LAURANCE *et al*., 2004; NOBRE *et al*., 1991), consequentemente, ameaça a conservação da biodiversidade (MALHI *et al*., 2008). Mudanças climáticas causadas pelo desmatamento descontrolado podem aumentar as temperaturas e se tornar um desastre irreversível para o planeta (ARAGÃO *et al*., 2018; FEARNSIDE, 2006; HEGERL *et al*., 2006).

Entre 2004 e 2012, houve queda significativa nas taxas de desmatamento na região devido às políticas públicas, mas, a partir de maio de 2013, voltou a ser observado um crescimento considerável nesse indicador. Em 2016, foram aproximadamente 8.000 km^2 (19%) de floresta destruída e em 2018 foi próximo de 800.000 km^2. Com base na análise do aumento das taxas de desmatamento na Amazônia Legal, o estado do Pará destacou-se pela maior taxa na Região Norte – 34% do total (PRODES, 2018).

As razões apresentadas para justificar o declínio do desmatamento no Brasil, entre 2004 (atingiu 27,7 mil km^2) e 2012 (caiu para 4,4 mil km^2), foram as políticas públicas adotadas, ações da sociedade civil e políticas econômicas realizadas pelo governo brasileiro (ARAGÃO *et al*., 2018), como a implementação do Plano de Ação de Prevenção e Controle do Desmatamento na Amazônia (APPCDAm), em 2004, bem como a criação e manutenção de áreas protegidas (APs).

Houve uma reversão nesse cenário nos últimos anos e o desmatamento voltou a crescer, principalmente após a aprovação do novo Código Florestal (Lei 12.651, 2012) (ASSUNÇÃO *et al*., 2012) com regras flexíveis em relação à lei de 1965. Essa mudança representou um desafio para o governo nacional (KROGER, 2017).

O Brasil enfrenta o desafio de equilibrar o crescimento da produção agrícola com as áreas de proteção ambiental (GIL *et al*., 2015). A capacidade de atender à demanda do mercado de alimentos, combustíveis e energia tem sido uma das preocupações do país para as próximas décadas, levando em consideração a necessidade de tal expansão na agricultura e pecuária sem ameaçar as áreas de proteção ambiental, uma vez que o Brasil é um dos maiores produtores mundiais (NEPSTAD *et al*., 2009).

A criação de APs é vista como uma das políticas mais eficazes para garantir a conservação da biodiversidade em todo o mundo (STOLTON; DUDLEY, 2010; WATSON *et al*., 2014), tornando-se estratégia essencial para reduzir o desmatamento. A superfície das APs na Amazônia brasileira dobrou entre 2000 e 2009. Em 2019 atingiu 2.000.000 km^2, pressionando as taxas de desmatamento para baixo (PEREIRA *et al*., 2019).

As terras indígenas (TIs) estão entre as APs que mais contribuem para reduzir o desmatamento. O efeito inibidor exercido pelas TIs sobre o desmatamento amazônico também é observado quando se considera a área desmatada na região. Até 2014, quase 20% da área florestal da Amazônia brasileira foi desmatada, mas foi inferior a 2% em TIs, fato que comprova seu efeito redutor no desmatamento (CRISOSTOMO *et al*., 2015).

Os povos indígenas são guardiões da maior floresta tropical do planeta há milhares de anos (RICKETTS *et al*., 2010; WALKER *et al*., 2020). Ocuparam a Amazônia com práticas e estratégias de gestão ambiental (WATLING *et al*., 2017), como a domesticação de plantas e animais (LEVIS *et al*., 2017), e mudanças no solo com base no fogo controlado (SCHMIDT *et al*., 2014). Essa prática levou à melhoria da paisagem local e à melhor heterogeneidade entre as espécies florestais, especialmente as raras. Evitou também o acúmulo de combustíveis (folhas, galhos e troncos de árvores mortas) que poderiam causar incêndios naturais. Esses povos deram importantes contribuições para a biodiversidade amazônica desde a era pré-colombiana até os tempos atuais (FRANCO-MORAES *et al*., 2019; POSEY, 1985).

Esses povos também estabelecem relações com o meio ambiente que vão além da simples extração de recursos (RAMOS, 1995). Ao valorizar seu modo de vida tradicional, os índios protegem a biodiversidade, o direito à terra e à subsistência (MARETTI *et al*., 2014). Portanto, desempenharam papel fundamental na formação da biodiversidade encontrada na América do Sul. Por exemplo, muitas espécies vegetais, como castanha-do-Brasil, cacau e mandioca, e um grande número de espécies da fauna, surgiram como produtos de interação e formaram o manejo florestal com base nos modos tradicionais, esse processo foi responsável pela conservação e diversidade biológica dos ecossistemas (BATISTA *et al*., 2020). As práticas de uso da terra são diferentes dependendo do conhecimento tradicional desses povos, que é combinado com seu modo de vida tradicional e perspectiva moderna sobre o uso sustentável da terra (STEVENS *et al*., 2014; TAULI-CORPUZ *et al*., 2018).

Estima-se que esses povos compreendem 1,7 milhão de indivíduos distribuídos em 375 grupos indígenas que vivem em aproximadamente 3.344 territórios indígenas em todo o país, bem como nos limites biogeográficos da Amazônia. As TIs no Brasil abrangem 721 áreas e ocupam 13,8% do território nacional (1.174.263 km^2) (ISA, 2019). A maioria delas está localizada na Amazônia Legal, que tem 115,3 milhões de hectares (Mha) distribuídos em 414 TIs tradicionalmente ocupadas (FANY *et al*., 2015). As TIs representam aproximadamente 23% do território amazônico. Estão localizadas em florestas bem conservadas em um mosaico de APs que cobrem a região amazônica (COSTA, 2019).

O estado do Amapá, localizado no Norte do Brasil, possui uma das maiores biodiversidades e abriga uma combinação diversificada de ecossistemas (MUSTIN *et al*., 2017). É o estado mais protegido do Brasil, dado seu isolamento histórico e a presença de várias APs (PERES *et al*., 2014). Os governos federal e estadual foram bastante ativos na definição de APs e terras indígenas que, ao todo, abrangem 72% do estado (CUNHA *et al*., 2019). Conta com 19 APs, 12 sob administração federal, cinco geridas pelo estado e duas geridas pelos municípios (BRITO, 2008), e com cinco terras indígenas (Wajãpi, Uaçá, Galibi, Juminã e Parque Nacional Montanhas do Tumucumaque).

TIs no Amapá somam 9.635 habitantes espalhados em aldeias. Ao todo, conservam mais de 11.256,71 km^2 de florestas. Esses povos são etnicamente diferentes e têm costumes, modos de vestir, modelo econômico e agricultura diferentes, mas são semelhantes na luta por direitos e na preocupação com a sustentabilidade. Esses povos se uniram para proteger seu território, e todas as TIs foram demarcadas em 1970 e homologadas na década de 1990 (GALLOIS; GRUPIONI, 2003). Com base nesse cenário, o presente estudo testou a hipótese de que a população indígena cresceu, mas não resultou em áreas desmatadas, pois a sustentabilidade dessas áreas é garantida pela forma como esses povos as gerenciam.

2 MATERIAIS E MÉTODOS

2.1 ÁREA DE ESTUDO

O estudo foi realizado em quatro TIs localizadas no estado do Amapá (Figura 1), Norte do Brasil. Nas TIs vivem as etnias Wajãpi, Uaçá, Galibi e Juminã.

A TI Wajãpi (Figura 1a) está localizada nos municípios de Pedra Branca do Amapari e Laranjal do Jari, centro-oeste do Amapá. Abriga aproximadamente 1.500 pessoas em uma área demarcada com aproximadamente 607.000 ha (APINA; AWATAC; IEPÉ, 2017). A TI Wajãpi faz divisa com as APs Parque Nacional Montanhas do Tumucumaque, Reserva de Desenvolvimento Sustentável do Rio Iratapuru, Floresta Estadual do Amapá, Reserva Extrativista Beija-Flor Brilho de Fogo e projeto de assentamento Perimetral Norte, na BR-210 (MORENO et al., 2018).

As TIs Uaçá, Galibi e Juminã, localizadas norte do Amapá (Figura 1b), são conhecidas como "Os Povos Indígenas do Baixo Oiapoque" (SANTOS; SANTOS, 2017). A população das três TIs soma 8.109 habitantes: 7.659 em Uaçá, 164 em Galibi e 286 em Juminã, e está dividida em mais de 50 aldeias (DSEI, 2019). Essas TIs estão demarcadas em uma grande área contínua com 518.654 ha: Uaçá com 470.164 ha, Galibi com 6.889 ha e Juminã com 41.601 ha (SANTOS; SANTOS, 2017). As TIs são cortadas a oeste pela BR-156. As TIs Juminã e Galibi fazem fronteira ao norte do estado do Amapá com a Guiana Francesa. A TI Uaçá faz fronteira a oeste com o Parque Nacional Cabo Orange (TASSINARI, 2003; VIDAL, 2013).

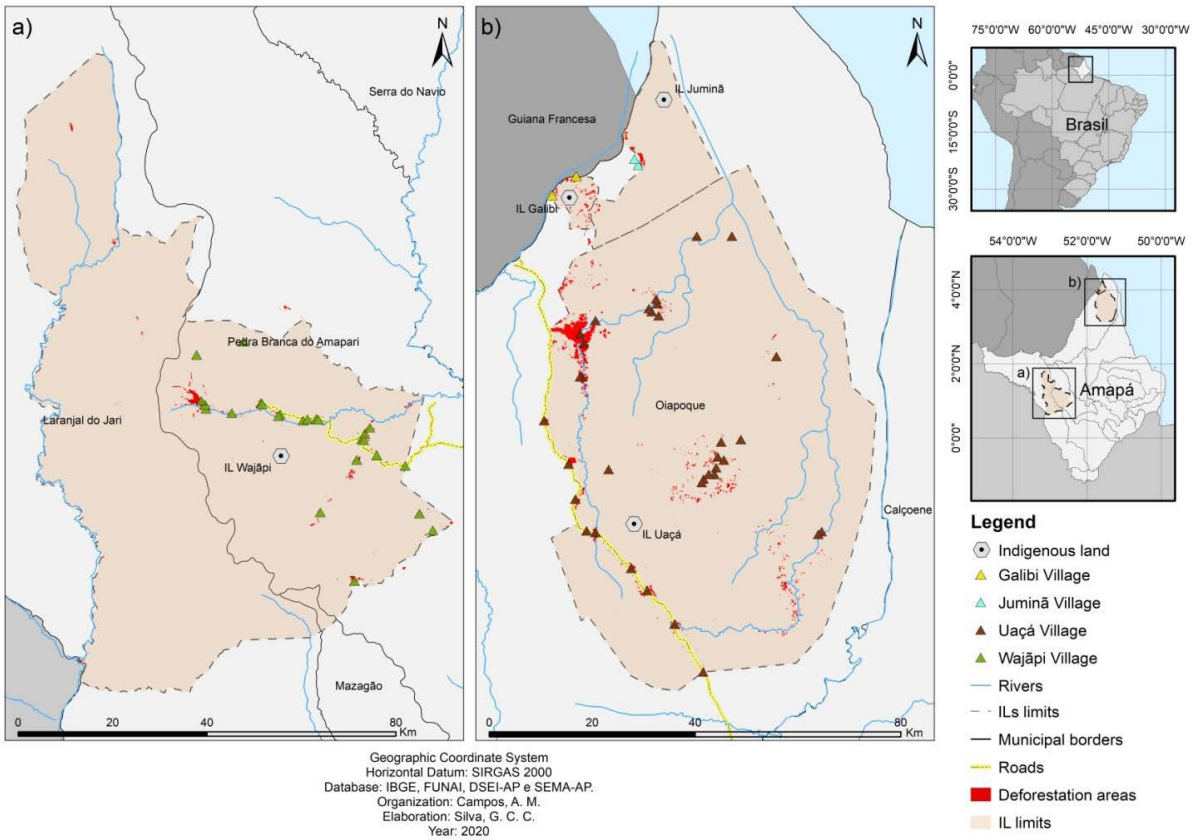

Figura 1 | TIs no estado do Amapá: a) Wajãpi e b) TIs Oiapoque: Uaçá, Galibi e Juminã.

Fonte: Autores

2.2 COLETA DE DADOS

A pesquisa foi aprovada pelo Comitê de Ética da Unifap (CAEE 10800919.0.0000.0003) e utilizou dados secundários das TIs: crescimento populacional (disponibilizados pelo Distrito Sanitário Especial Indígena do Amapá/DSEI-AP), dados de nascimento e óbitos, e dados de desmatamento (disponibilizados pela Secretaria de Estado do Meio Ambiente/Sema-AP). Os dados dizem respeito a uma série histórica de 2002 a 2018.

Os dados de desmatamento foram coletados por meio de sensoriamento remoto pelo satélite Landsat 5, disponibilizado pelo Instituto Nacional de Pesquisas Espaciais (INPE, 2013). Os shapes, para quantificar o desmatamento, foram disponibilizados pela Sema. Embora a quantificação do desmatamento na Amazônia seja realizada pelo Inpe, por meio do Projeto de Estimativa do Desmatamento da Amazônia/ Prodes, o estado do Amapá não é avaliado satisfatoriamente devido à alta nebulosidade na maior parte do ano (SEMA-AP, 2014), que impossibilitou a obtenção de imagens de satélite de boa qualidade. A análise das imagens é de novembro, mês com menos nuvens na região Norte.

A Sema trabalha com parâmetros originais de imagem, pixels de 30x30 metros, pois permite mapear uma área menor: aproximadamente 0,1 ha. Utilizamos conceitos de desmatamento, como o corte raso, que é utilizado pelo Inpe no Prodes e é caracterizado pela remoção total da cobertura florestal em um curto período de tempo: maior que 6,25 ha do corte em floresta primária (INPE, 2013). Muitas vezes, um corte raso é feito para plantar outra cultura, seja agrícola ou florestal, a chamada “conversão” (FAO, 1989; FLOR, 1985).

2.3 ANÁLISE ESTATÍSTICA

Os dados de crescimento populacional e desmatamento das TI’s do Amapá foram organizados em planilhas do Microsoft Excel 2007®, sendo posteriormente verificada a normalidade dos dados pelo método de Shapiro-Wilk usando o aplicativo RStudioVersion 1.0.153®. Com a normalidade dos dados, foi aplicado o coeficiente de correlação de Pearson (r) para medir o grau de relação entre as variáveis, confirmada pela regressão linear (r2), usada para verificar o resíduo quadrático dos dados. Os testes foram realizados com o auxílio do aplicativo RStudioVersion 1.0.153®. O universo do estudo é equivalente ao total das áreas com grau de confiabilidade dos dados de 100%. Os shapes dos desmatamentos foram analisados pelo Software Microsoft Excel 2007® e QGIS 3.10®.

Após a tabulação dos dados, foi possível observar a falta de dados de desmatamento devido aos problemas técnicos causados por nuvens nas áreas indígenas ao longo do ano (informações da Sema). No entanto, há o valor acumulado de um ano para o outro, sabendo-se que as áreas desmatadas já contabilizadas no ano anterior não foram contabilizadas no ano seguinte. Nesse caso, foi realizada a interpolação linear dos dados ausentes apenas para realizar a estimativa e a densidade demográfica. O método de interpolação linear utilizou dados de registro superior e inferior. O critério adotado para encontrar X (campos vazios) entre valores a e b (campos com dados) foi $\{x \in R \mid a < x < b\}$, usando a lei de formação da reta $f(x) = ax + b$ (ARENALES; DAREZZO, 2008; RIBEIRO, 2014).

A equação 1 foi usada para encontrar a densidade demográfica, na qual d é densidade, A é a área total demarcada em km² e n é o número total de habitantes por ano.

$$d = \frac{A}{n} hab/Km^2 \qquad (1)$$

Para modelar o desmatamento das TIs até 2028, o valor do desmatamento foi calculado pela função linear ajustada pelo método dos mínimos quadrados, a partir dos dados de crescimento populacional e desmatamento, obedecendo aos critérios das seguintes equações:

Lei de formação da reta f(x) = ax + b gerada a partir dos dados tabulados e interpolados. Para encontrar o valor de a temos a equação 2a e para encontrar o valor de b temos a equação 2b:

$$a = \frac{(n.\sum xy)-(\sum x.\sum y)}{(n.\sum x^2)-(\sum x)^2} \quad (2a)$$

$$b = \frac{(\sum x.\sum xy)-(\sum y.\sum x^2)}{(\sum x)^2-(n.\sum x^2)} \quad (2b)$$

Devido à ausência de dados de desmatamento, em alguns períodos para as TIs Galibi e Juminã, não se realizou a análise de regressão linear das variáveis crescimento populacional e desmatamento. Para maior confiabilidade, os dados ausentes não foram interpolados. As análises das variáveis foram realizadas para as TIs Uaçá e Wajãpi que apresentaram menos ausência de dados.

3 RESULTADOS

3.1 DEMOGRAFIA

De 2002 a 2018, a população indígena no estado do Amapá aumentou mais de 50% se levarmos em conta o número de óbitos no mesmo período. A TI Uaçá dobrou sua população em mais de 4.000 habitantes (56%), apesar da alta média anual de 15 óbitos. A TI Juminã apresentou aumento populacional de 40%, com média anual de um óbito. A TI Galibi registrou menor crescimento populacional (23%), com média anual de dois óbitos, enquanto a TI Wajãpi registrou aumento populacional de 57% e foi a segunda TI com maior registro de óbito (6 em média/ano) (Figura 2)

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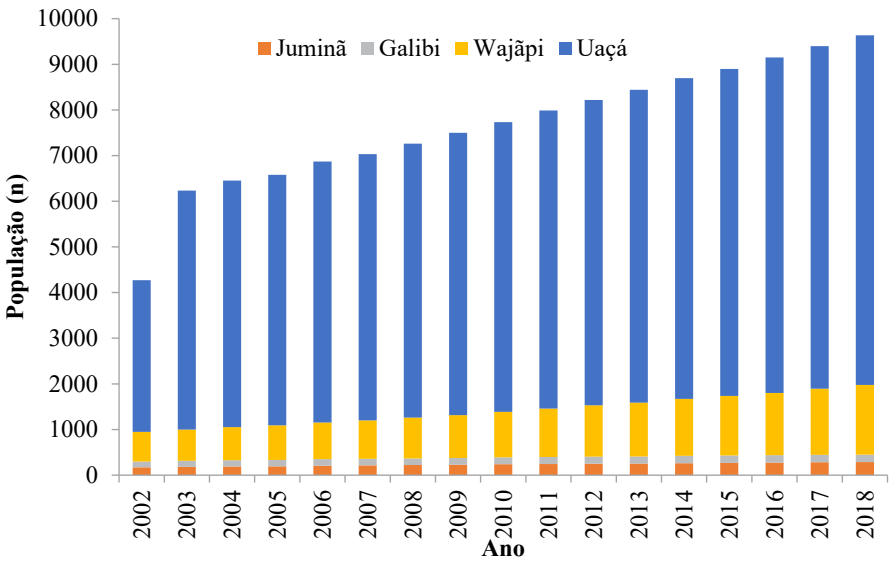

Figura 2 | Comparação anual do crescimento populacional nas TIs do Amapá.

Fonte: Autores

A densidade demográfica (Tabela 1) nas TIs foi baixa. A maior média de densidade demográfica foi 2,1 hab/km2, registrada para Galibi, seguida por Uaçá (1,51 hab/km2), Juminã (0,56 hab/km2) e Wajãpi (0,17 hab/km2). Na TI Wajãpi foi encontrada a menor densidade demográfica em 2002 (0,11 hab/km2) e a maior densidade em 2018 (0,25 hab/km2). A maior densidade foi registrada para Galibi (2,38 hab/km2) em 2018.

Considerando dados do censo de 2010 do IBGE, a densidade demográfica do município de Oiapoque era de 0,91 hab/km2, Laranjal do Jari era de 1,29 hab/km2 e Pedra Branca do Amapari era de 1,29 hab/km2. Assim, a TI Galibi, nesse mesmo ano, apresentou dados superiores à densidade do Oiapoque, enquanto a TI Wajãpi apresentou dados inferiores à densidade de Laranjal do Jari e Pedra Branca do Amapari.

Tabela 1 | Comparação anual da densidade demográfica nas TIs do Amapá.

Ano	*Juminã*	*Galibi*	*Wajãpi*	*Uaçá*
2002	0.42	1.83	0.11	0.71
2003	0.44	1.92	0.11	1.11
2004	0.46	1.97	0.12	1.15
2005	0.47	2.02	0.13	1.17
2006	0.50	2.06	0.13	1.22
2007	0.52	2.08	0.14	1.24
2008	0.53	2.12	0.15	1.28
2009	0.55	2.13	0.16	1.31
2010	0.58	2.18	0.16	1.35
2011	0.59	2.24	0.18	1.39
2012	0.60	2.25	0.19	1.42
2013	0.61	2.28	0.19	1.46
2014	0.63	2.34	0.21	1.49
2015	0.65	2.34	0.22	1.52
2016	0.66	2.37	0.22	1.56
2017	0.68	2.40	0.24	1.60
2018	0.69	2.38	0.25	1.63

Os dados em azul foram interpolados.

Fonte: Autores

3.2 DESMATAMENTO

O desmatamento acumulado até 2002 na TI Wajãpi foi de 482 ha (Figura 3a). A TI Uaçá apresentou o maior desmatamento acumulado (2.793 ha), seguida pela TI Galibi (351 ha) e Juminã, com o menor desmatamento acumulado (120 ha) (Figura 3b).

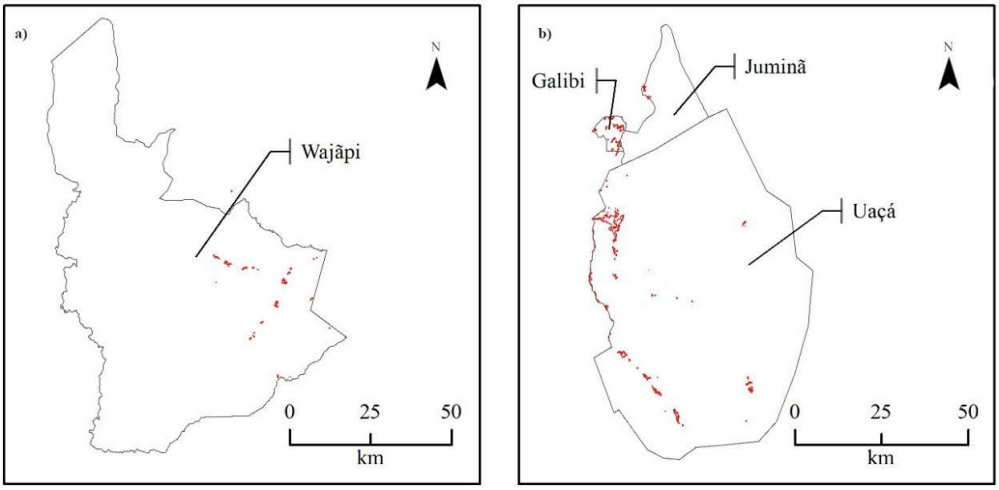

Figura 3 | Desmatamento acumulado até 2002 nas TIs: a) Wajãpi, b) Oiapoque.

Fonte: Autores

O desmatamento acumulado até 2018 na TI Wajãpi (Figura 4a) foi 2.312 ha, Uaçá foi 7.883 ha, Galibi foi 560 ha e Juminã foi 363 ha (Figura 4b).

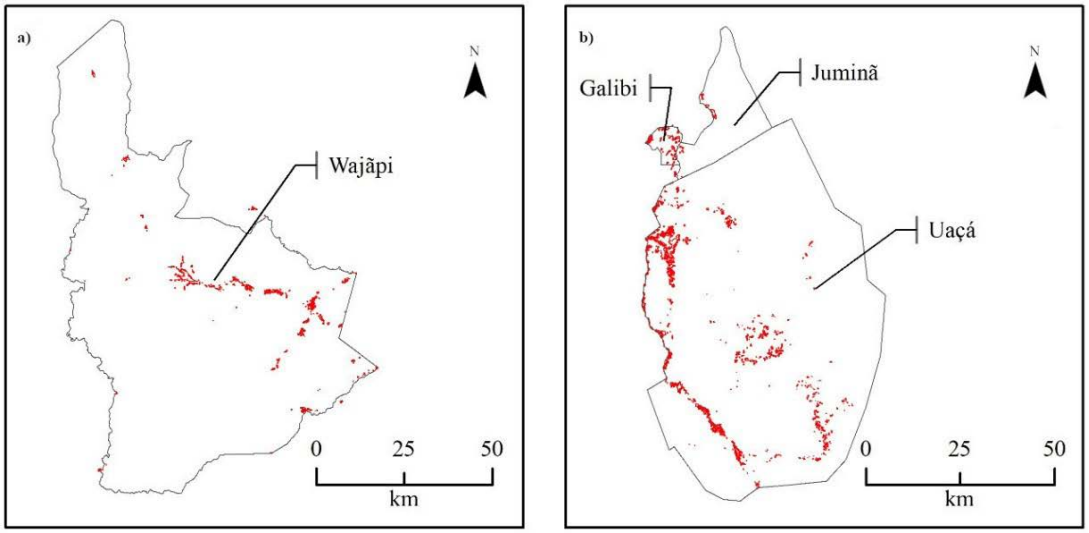

Figura 4 | Desmatamento acumulado até 2018 nas TIs: a) Wajãpi, b) Oiapoque.

Fonte: Autores

Em 2002, as quatro TIs tiveram picos de uso da terra (Figura 5). Na TI Wajãpi, o desmatamento oscilou entre valores altos e baixos: 474 ha (2002); 39 ha (2005); 537 ha (2012) e 154 ha (2015). Uaçá apresentou valores altos: 615 ha (2008); 1.067 ha (2012 e 956 ha (2018). Por outro lado, os números da TI Galibi declinaram, 104 ha (2002); 89 ha (2004); 19 ha (2014) e 22 ha (2018). Juminã, apesar da forte correlação entre as variáveis, apresentou valores baixos: 40 ha (2002) e 12 ha (2006), mas houve aumento de 148 ha em 2018.

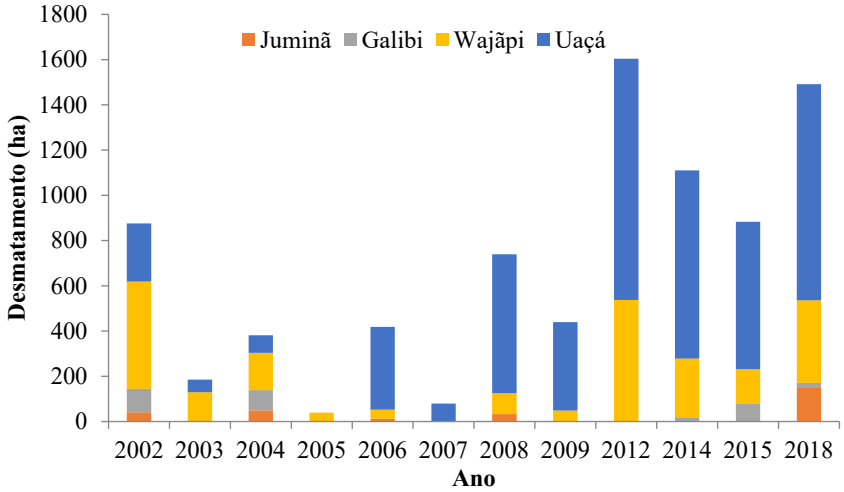

Figura 5 | Comparação do desmatamento em hectares nas TIs do Amapá – de 2002 a 2018.

Fonte: Autores

O desmatamento médio nas TIs variou de 16,69 ha (Juminã) a 314,54 ha (Uaçá). No entanto, em 18 anos, a Galibi utilizou aproximadamente 10% do total de suas terras (6.889 ha) e Wajãpi não chegou a 1% (607.017 ha), mesmo considerando o desmatamento acumulado em 1999 e os dados interpolados.

Embora Uaçá seja a segunda maior em extensão territorial (470,16 ha), também foi a primeira no ranking de crescimento populacional, aproximadamente 7.000 habitantes e a primeira em desmatamento. A Uaçá utilizou 2% do total de sua terra até 2018 (desmatamento acumulado e interpolado).

Com base no teste estatístico Shapiro-Wilk, Wajãpi apresentou P-value = 0,23 para variável "população" e P = 0,06 para a variável "desmatamento", ambos em P > 0,05, comprovando a normalidade dos dados. A regressão linear apontou que menos de 1% (r2 = 0,096) da população explica o desmatamento observado nessa TI. Esse resultado justifica a não realização de outras análises, bem como da estimativa de população e desmatamento até 2028. Uaçá apresentou valor P = 0,44 para população e P = 0,33 para desmatamento, ambos para P > 0,05. Os dados de Uaçá também foram normais e sua regressão linear mostrou que aproximadamente 50% (r2 = 0,492) da variável "população" explica o desmatamento nessa TI.

Em 2002, Uaçá registrou desmatamento de 257 ha para uma população de 3.332 pessoas. Em 2003 e 2007 houve redução significativa do uso da terra, mesmo que se leve em conta o aumento populacional. Houve pico de desmatamento em 2008 (615 ha) e aumento populacional com mais de 6.000 pessoas. Houve redução de aproximadamente 50% no desmatamento em 2009 em relação ao ano anterior. Embora tenha ocorrido redução nos registros de desmatamento, a população continuou crescendo. A partir de 2010, observaram-se oscilações de dados de desmatamento, pico elevado em 2012 (1.070 ha) e crescimento populacional de 6.689 habitantes. Após 2012, o maior desmatamento foi registrado em 2018, equivalente a 956 ha e população de 7.659 habitantes (Figura 6).

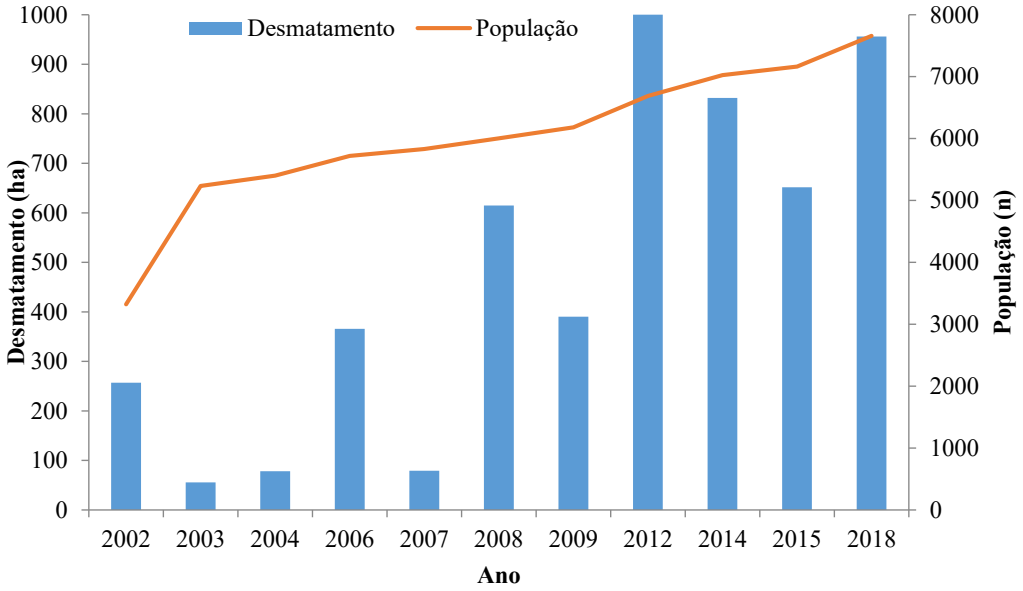

Figura 6 |Comparison between population number and annual deforestation in Uaçá IL.
Source: Elaboration of the authors.

3.3 ESTIMATIVAS DE DESMATAMENTO

A análise da modelagem para estimar a população e o desmatamento até 2028 (10 anos) não foi realizada para as TIs Galibi e Juminã devido à ausência de dados. Não foi possível modelar para a TI Wajãpi, pois as análises de Pearson apontaram uma relação fraca (r = 0,31) entre as variáveis, comprovada pela regressão linear.

Assim, a modelagem foi realizada para a TI Uaçá; alguns dados de desmatamento ausentes foram interpolados. De acordo com o Teste de Pearson, Uaçá apresentou uma correlação forte (0,74) entre as variáveis, confirmada pela análise da regressão linear, que 0,55% das variáveis estudadas (crescimento populacional e desmatamento) explicam que há forte correlação entre elas. Assim, o aumento do desmatamento e o crescimento populacional são contínuos nessa TI (Figura 7)

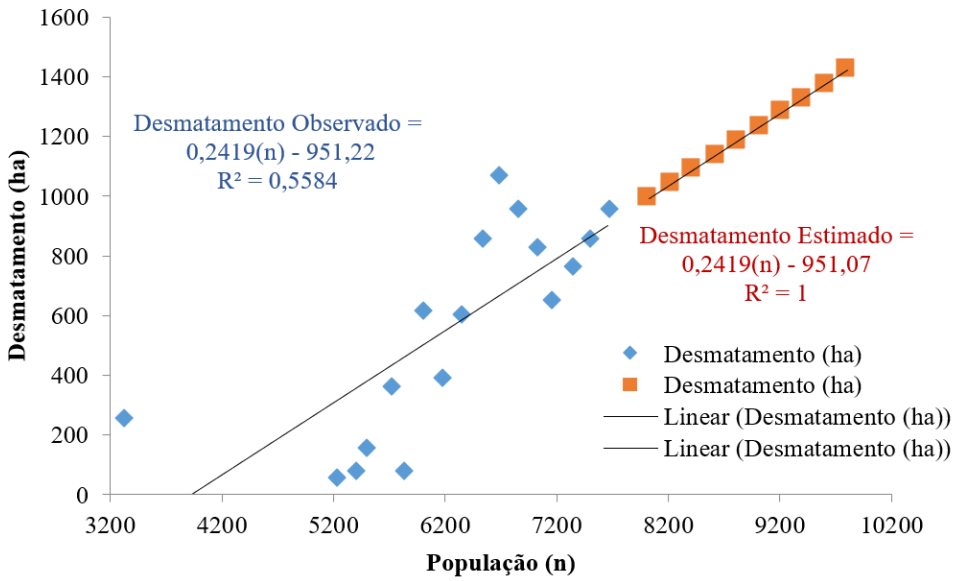

Figura 7 | Estimativas de crescimento populacional e de desmatamento até 2028 na TI Uaçá.

Fonte: Autores

Até 2028, a população terá um aumento de aproximadamente 1.800 habitantes a mais que o registrado em 2018, e um desmatamento igual a 1.421,97 ha para o mesmo ano. Haverá uma diferença de quase 466,09 ha, no intervalo de 10 anos. Houve crescimento exponencial tanto na população quanto no desmatamento. Até 2028, a população da TI Uaçá utilizará 4,6% do total de seus 470 ha, mesmo com amplo uso da terra para atividades de produção voltadas à subsistência e fornecimento local de farinha de mandioca.

4 DISCUSSÃO

4.1 DEMOGRAFIA

A partir da relação entre os dados demográficos, crescimento populacional, número de óbitos e densidade demográfica, foi observado crescimento populacional contínuo na TI Wajãpi. No entanto, o povo Wajãpi já foi considerado mais numeroso; a queda no número de habitantes ocorreu em um surto de malária causado pelo contato com os não índios (APINA; AWATAC; IEPÉ, 2017).

A densidade demográfica nessa TI não chegou a 1 hab/km², mesmo considerando os anos de maior desmatamento. Isso se explica pelo tamanho de sua área (607.000 ha) e uma população de aproximadamente 1.500 habitantes. Essa TI registrou média de nascimentos de 52 pessoas/ano, tem baixo uso da terra, pois utilizou 0,63% de seu território e o restante foi conservado.

Isso reforça a importância de se manter APs extensas, nas quais os povos indígenas desempenham papel importante para a conservação dos ecossistemas para as futuras gerações (GARNETT et al., 2018), além de preservar a sua cultura e seus conhecimentos tradicionais.

A relação das variáveis crescimento populacional e desmatamento na TI Wajãpi foi fraca, não influenciou diretamente o uso da terra, ou seja, a tendência do desmatamento em relação à população é de estabilidade. Os Wajãpi vivem isolados, cercados por APs e possuem costumes tradicionais. O uso reduzido do solo para a agricultura, a abertura de roças e a construção de casas, por exemplo, nessa TI, devem-se aos seus costumes.

O tempo de uso da roça e o seu manejo são fatores relevantes para a redução do uso da terra. Os wajãpi usam a mesma roça por aproximadamente 20 anos e, após o uso, deixam a terra em pousio e abrem outra roça ao lado da anterior. Eles deixam uma faixa de floresta primária entre uma roça e outra para acelerar a regeneração natural (APINA; AWATAC; IEPÉ, 2017). É importante ressaltar que as florestas secundárias desempenham papel fundamental na conservação da biodiversidade e na prestação de serviços ecossistêmicos, como a fixação de carbono (POORTER et al., 2016).

As roças dos povos indígenas do Amapá são familiares, assim, exigem tamanho específico (aproximadamente 1 a 3 ha, dependendo do interesse e necessidade de cada família e da disponibilidade de recursos). Segundo Silveira (2015), a escolha dos limites do tamanho das roças está relacionada aos elementos da natureza, como rios, cachoeiras, disponibilidade de caça e coleta de frutas, sementes e materiais para artesanato e construção de casas.

Os povos indígenas há muito reconhecem a importância de conservar e gerenciar adequadamente suas terras, não apenas porque elas fornecem suas necessidades materiais, mas porque reforçam ou redefinem seu compromisso tradicional com a terra (GARNETT et al., 2018).

De todas as TIs, a Uaçá foi a que mais cresceu, mesmo com média anual alta de óbitos em relação às demais TIs. Segundo informações do DSEI-AP, as maiores causas de óbito em TIs no Amapá estão relacionadas a doenças parasitárias.

Embora Uaçá tenha apresentado as maiores taxas de desmatamento e crescimento populacional, sua densidade demográfica não atingiu 2 hab/km^2. O uso da terra, até 2018, foi baixo, mesmo utilizando-a para a agricultura. Assim, a forte dependência dos recursos naturais, a relação de sua estrutura organizacional, bem como seus sistemas de manejos próprios, desenvolvidos por gerações, somados ao isolamento de suas áreas, configuram fortes elementos de conservação (DIEGUES et al., 2000).

A relação entre as variáveis “crescimento populacional” e “desmatamento” na TI Uaçá foi forte, e esse achado confirmou estatisticamente a tendência de crescimento entre as variáveis. Esse povo faz uso extensivo da terra porque cultiva mandioca (em larga escala) para comercializar no município de Oiapoque e para subsistência. Apesar do cultivo para o comércio local, o desmatamento foi baixo em comparação com outras TIs da Região Norte, como a TI Puyanawa, no Alto Juruá (AC), que possui 16 casas de farinha para abastecimento local. O povo Puyanawa é conhecido como grande produtor de farinha: aproximadamente 500 toneladas/ano, além do uso da terra aplicado a outras cultivares frutíferas, que fazem parte de sua dieta, como o açaí (FOWLER, 2020).

Mesmo quando há mudanças na cultura indígena, com adoção de valores da sociedade de mercado do não índio, os povos indígenas mantêm suas práticas de cultivo sustentáveis. As mudanças de cultivo em florestas tropicais muitas vezes envolvem práticas de limpeza para cultivar alimentos e produtos florestais não madeireiros (usados na construção de casas e artesanatos, que são fontes de renda). A exaustão de nutrientes do solo ou infestação de pragas agrícolas são razões para deixar a terra descansar, para que a floresta possa se recuperar e começar a crescer novamente (BECKERMAN, 1987).

Quanto ao crescimento populacional na TI Galibi, este foi o menor em relação às TIs do Oiapoque. A tendência nessa TI é de estabilidade populacional, apesar de sua baixa taxa média anual de mortalidade. A média anual de nascimentos de 2002 a 2018 foi 1,3 pessoa. Os óbitos foram registrados para crianças menores de 1 ano e pessoas com mais de 50 anos – há vários idosos com idade próxima dos 100 anos (DSEI, 2019). Esses dados confirmam que o crescimento populacional na TI Galibi vem diminuindo, portanto, haverá redução do uso da terra. A TI Galibi registrou a maior densidade demográfica (perto de 3 hab/km^2). Deve-se levar em conta que, apesar da alta densidade, possui o menor território (6.889 ha), e isso não influenciou o desmatamento.

A TI Juminã registrou baixo crescimento populacional e baixa média anual de óbito. Sua densidade demográfica é baixa, assim como suas taxas de desmatamento, exceto nos anos em que se observou maior crescimento populacional e desmatamento. Essa TI produz farinha de mandioca e tem cultivares de batata-inglesa, batata-doce, hortaliças e árvores frutíferas, apenas para subsistência, o que não ocupa grandes extensões de terra. Assim, o crescimento populacional não influenciou negativamente o aumento do desmatamento.

A densidade demográfica dos povos indígenas no Amapá é bem menor do que em outras TIs no Brasil. A densidade demográfica dos povos indígenas da Reserva Indígena de Dourados (MS) foi a maior entre os povos indígenas do Brasil até 2013 (300 hab/km^2) (BARBOSA et al., 2016). Entretanto, a maior parte das TIs no Brasil possui baixa densidade demográfica, a exemplo da Reserva Extrativista do Rio Xingu Terra do Meio (PA), com 0,81 hab/km^2 onde residem populações ribeirinhas e povos indígenas (Arara, Kuruaya, Parakanã, Xikrin e Xipaya) (ISA, 2020). Em 2008 a densidade demográfica da TI Raposa Serra do Sol (RR) era de 1,1 hab/km^2 e população aproximada de 19 mil habitantes (povos Macuxi, Wapichana, Taurepang, Patamona e Ingarikó) em 1.747.464 hectares (USP, 2020).

4.2 DESMATAMENTO

Todas as TIs tiveram picos de desmatamento de 2002 a 2018, mas o crescimento populacional não o influenciou. Houve momentos em que era possível observar o alto desmatamento em todas as TIs. Vale ressaltar que TIs próximas de rodovias podem sofrer ameaça de desmatamento. Há uma forte relação entre a área desmatada e a influência da malha rodoviária no processo de desmatamento (NEVES *et al*., 2021).

Assim, a TI Uaçá registrou a maior taxa de desmatamento em relação às demais TIs. Tal desmatamento pode ser justificado pelo intenso uso da terra para o cultivo de mandioca destinado à produção de farinha para abastecer o mercado local.

A estratégia ambiental para a formação da floresta secundária, adotada pelo povo Wajãpi, é também adotada pelos povos kayapó (Rio Xingu, Brasil). As manchas florestais entre as culturas agrícolas são chamadas de "apetês". Além de garantir a formação de florestas secundárias, os apetês, em tempos de guerra, funcionam como barreiras, parapeitos e linhas de defesa para a aldeia indígena; em tempos de paz, eles são usados como lugares para descansar, para passar as horas mais quentes do dia (POSEY, 1985).

A sucessão secundária diz respeito à substituição dos organismos por outros tipos de organismos de um ambiente que foi perturbado, por exemplo, por furacões, eventos de seca, deslizamentos de terra causados pelo vento, práticas agrícolas de corte, queima ou agricultura intensiva (ERICKSON; BALÉE, 2006). Essa influência do manejo humano também altera a biodiversidade amazônica.

A biodiversidade amazônica foi influenciada pelo manejo humano, por exemplo, nas diferenças na abundância relativa de espécies entre florestas ancestrais e antigas que não estão relacionadas às próprias condições do solo, mas ao manejo humano anterior (FRANCO-MORAES *et al*., 2019). Os povos indígenas do Amapá gerenciam suas terras visando o seu futuro e o futuro da floresta. O conhecimento tradicional desses povos abrange práticas de manejo que limitam distúrbios ambientais de baixa intensidade para garantir a estabilidade e a resiliência dos ecossistemas (BEGOSSI *et al*., 2000). Assim, ficou comprovado que as populações indígenas antigas tinham um estilo de vida híbrido, que incluía pesca, caça, extração, colheita de frutas e manejo florestal. Esse processo permitiu a dependência não total da agricultura (ROWLEY-CONWY; LAYTON, 2011). Essas populações manejavam florestas e abriam espaço para criar sistemas agroflorestais, enriquecendo-as com espécies úteis e suprimindo espécies indesejadas (ERICKSON; BALÉE, 2006).

Ao longo dos anos, foi possível observar que a tendência dos povos indígenas de proteger suas florestas contra o desmatamento se perderia à medida que esses grupos começassem a adotar costumes não indígenas, o que também aumentaria sua densidade demográfica (TERBORGH; VAN SHAIK, 2002). Nepstad *et al*. (2006) testaram essa hipótese e avaliaram a "resposta da inibição do desmatamento por reservas indígenas desde o primeiro contato com grupos não indígenas e à densidade demográfica". Esse estudo também foi realizado a partir da análise de imagens de satélite, e os autores chegaram à conclusão que as comparações testadas não produziram nenhuma relação significativa. Assim, confirmaram que as reservas indígenas inibem o desmatamento, a relação de uso da terra com a perturbação da floresta é fraca, mas é relativamente alta nas áreas habitadas e invadidas.

4.3 ESTIMATIVAS DE DESMATAMENTO

Uma pesquisa sobre a estimativa de desmatamento no estado do Amapá até 2030 mostrou que, embora o estado apresente perfil geográfico isolado em comparação com o resto do país, o que contribui para o alto grau de preservação da cobertura vegetal nativa, o desmatamento vem crescendo nas últimas décadas (LESS *et al.*, 2018).

Diferente dos resultados encontrados por Less *et al*. (2018), as estimativas de aumento do desmatamento e crescimento populacional na TI Uaçá foram baixas, se levarmos em conta uma projeção de 10 anos, até 2028. A modelagem estimada até 2028 apresentou baixo aumento no crescimento populacional e aproximadamente 50% a mais do desmatamento acumulado até 2018. No entanto, se levarmos em conta o tamanho da terra e a forma como ela é utilizada, isso não terá influência negativa sobre a cobertura florestal. Segundo Fearnside *et al*. (2009), o desmatamento dentro das TIs não é levado em consideração, uma vez que o uso da terra tem baixo impacto e visa a subsistência.

O modelo de organização social baseado na baixa densidade populacional e alta mobilidade em todo o território, como o caso dos povos indígenas, juntamente com práticas de manejo baseadas no conhecimento tradicional e no uso consciente dos recursos naturais (pesca, caça, produtos não madeireiros e madeireiros), pode garantir não apenas a manutenção dos povos tradicionais, mas a biodiversidade e a conservação florestal (BEGOSSI *et al*., 2000; SMITH; WISHNIE, 2000).

Com base nos resultados, é possível afirmar que o tamanho do território é um fator importante para garantir a conservação da floresta e da biodiversidade, pois pode influenciar a efetividade da AP em conter o desmatamento. As APs que têm um tamanho menor apresentam desmatamento maior do que aquelas com grandes blocos de floresta ultrapassando os 10.000 km^2. Mesmo assim, as áreas menores e mais sujeitas à pressão antrópica conseguem conter o desmatamento, de maneira que o percentual interno deste é menor do que aquele fora dos seus limites externos (área em torno de 10 km^2) (VITEL; FEARNSIDE; GRAÇA, 2009).

5 CONCLUSÃO

Confirmamos a hipótese de que não há relação entre densidade demográfica em TIs no estado do Amapá e desmatamento, uma vez que a densidade nessas áreas é muito baixa, e sua sustentabilidade é garantida pela forma como os índios utilizam a terra, principalmente para culturas de subsistência. Os povos indígenas conservam suas terras e estão preocupados em usá-las de forma sustentável, baseada no conhecimento tradicional. Tal conhecimento sobre a importância de conservar e proteger as terras, e lutar por seus direitos é transmitido de geração em geração.

O desmatamento em TIs no Amapá foi baixo, e esse achado mostrou que essas áreas têm alto potencial de conservação florestal. As variáveis utilizadas no presente estudo apresentaram uma forte correlação

para todas as TIs, exceto Wajãpi, que apresentou correlação fraca, e a TI Galibi apresentou correlação forte negativa. Esta TI merece atenção da comunidade científica e de várias esferas governamentais, uma vez que sua população está em decrescimento. Acreditamos que isso não seja um fator comum entre os povos indígenas.

O tamanho da área é um fator importante para a conservação da vida, cultura e conhecimentos tradicionais, bem como para a garantia da conservação florestal e da manutenção da biodiversidade. Portanto, compreender o aumento do desmatamento e o crescimento populacional nas TIs é importante para prever quais medidas os líderes das comunidades indígenas e o governo do estado podem tomar para garantir a conservação da floresta e a manutenção da vida dos povos tradicionais.

A partir desta pesquisa, a realização de estudos e a avaliação da causa do baixo crescimento populacional nas TIs de Galibi e Juminã são medidas que podem ser levadas em consideração, pois sem esses povos, as terras poderão estar em risco de invasão de garimpeiros, exploração de madeira ilegal, caça e pesca. Além disso, é importante fortalecer as políticas públicas específicas para os povos indígenas em áreas como saúde e educação. Vale ressaltar a necessidade urgente de atenção à TI Uaçá, que apresentou elevada média anual de óbitos por problemas de saúde.

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In this last issue of 2021, the Journal Sustainability in Debate – SiD discusses about one of the biggest lessons of the year, reaffirming the importance of systemic and collaborative thinking as the best way to address our current global crisis (related with the pandemic of Covid-19 and climate change). Overall, it is urged for greater solidarity in local communities through bottom-up coordinated network actions.

This issue presents 13 articles in the section Varia, dealing with the following topics: sustainability in the textile industry; relationship between project management and green innovation in sustainable fabric companies; pre-consumption textile waste management in the clothing industry; management plan based on integrated and sustainable agroecological production for medicinal plants; perceptions of rice farmers and the importance of integrated actions to promote complex innovations in agriculture; the role of water infrastructure programs for family farmers in strengthening adaptive capacities to climate change; assessment of the Great Drought in the northeast of Brazil; a discussion on the water crisis in Sao Paulo; reactive (and not proactive) improvement of environmental policies; São Paulo's master plan from the point of view of principles and guidelines for a compact city, sustainable adaptation and ecosystem-based adaptation; the link between environmental management at the municipal level and the regional conservation of the Eastern Amazon; lessons learned from a participatory methodology of ecosystem services assessment in the Uruguayan Pampa biome; approaches to introducing gender budgeting in countries; and the role of indigenous lands in the Amapá State for forest conservation.

Neste último número de 2021, a Revista Sustainability in Debate - SiD discute sobre uma das maiores lições do ano, reafirmando a importância do pensamento sistêmico e colaborativo como a melhor forma de enfrentar a nossa atual crise global (relacionada à pandemia da Covid-19 e mudanças climáticas). De modo geral, é preciso haver maior solidariedade nas comunidades locais por meio de ações em rede coordenadas de baixo para cima.

Este número apresenta 13 artigos na seção Varia, tratando dos seguintes temas: sustentabilidade na indústria têxtil; relação entre gerenciamento de projetos e inovação verde em empresas de tecidos sustentáveis; gestão de resíduos têxteis de pré-consumo na indústria do vestuário; plano de manejo baseado na produção agroecológica integrada e sustentável de plantas medicinais; percepções dos produtores de arroz e a importância de ações integradas para promover inovações complexas na agricultura; o papel dos programas de infraestrutura hídrica para agricultores familiares no fortalecimento das capacidades de adaptação às mudanças climáticas; avaliação da Grande Seca no Nordeste do Brasil; uma discussão sobre a crise hídrica em São Paulo; melhoria reativa (e não proativa) das políticas ambientais; Plano Diretor de São Paulo do ponto de vista dos princípios e diretrizes de uma cidade compacta, adaptação sustentável e adaptação ecossistêmica; a ligação entre a gestão ambiental no nível municipal e a conservação regional da Amazônia Oriental; lições aprendidas com uma metodologia participativa de avaliação de serviços ecossistêmicos no bioma Pampa do Uruguai; abordagens para introduzir orçamentos de gênero nos países; e o papel das terras indígenas no Estado do Amapá para a conservação da floresta.

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