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Sustainability indicators in the context of nature-based tourism: a biocultural approach.

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ABSTRACT

In recent decades, researchers have widely studied the sustainability of nature-based tourism by developing and applying indicators. However, two key aspects remain underexplored: collecting socio-environmental data and incorporating community perceptions, which limit decision-making. This study aimed to: (1) investigate the development and use of effective management sustainability indicator systems in nature-based tourism; (2) examine how local populations directly involved in nature-based tourism perceive and engage with sustainability; and (3) propose a set of indicators based on a biocultural approach. We conducted the research in two stages: a systematic literature review and a field study in São Desidério, Bahia (Northeastern Brazil), involving interviews and a participatory workshop. We analyzed the data using content and frequency analyses. The review showed that most studies adopt an integrated approach (78%), but community participation remains limited (21% bottom-up; 79% top-down), weakening sustainability's social dimension. In the field study, the environmental dimension predominated in both tourism motivations and understandings of sustainability. Income generation emerged as the main benefit, while ecological degradation was identified as a major concern. The regionts expected tourism growth highlights the need to incorporate local perspectives into sustainable strategies. By integrating empirical and theoretical evidence, this study proposes a biocultural sustainability indicator system that captures local specificities, supports more inclusive public policies, and contributes to participatory processes and the valorization of local knowledge.

Keywords: Governance; Local perception; Social dimension; Sustainable tourism.

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SIGNIFICANCE STATEMENT

This manuscript advances discussions on sustainable tourism by examining the limitations of current sustainability indicators for nature-based tourism at national and local levels, with a particular focus on Brazil. Combining a systematic literature review with empirical and participatory approaches, the study highlights the insufficient incorporation of community perspectives and the persistence of top-down evaluation models. By integrating local knowledge with ecological, sociocultural, and economic dimensions, the research proposes an original analytical framework of biocultural indicators to improve monitoring, governance, and decision-making. The study contributes to environmental science by offering practical, context-sensitive strategies to reconcile biodiversity conservation and local development in megadiverse regions under increasing environmental pressure. Its findings offer relevant theoretical and applied contributions for researchers, policymakers, and tourism managers interested in more inclusive, socially grounded sustainability frameworks.

INTRODUCTION

Nature-based tourism has emerged as a rapidly growing recreational activity worldwide (Balmford et al. 2009; Karanth and DeFries 2011; Thapa et al. 2022). In this study, we adopt Thapa et al. (2022) definition, which describes this activity as any recreational practice carried out in natural environments, whether or not they are within protected areas. Therefore, nature-based tourism is an umbrella term that encompasses segments such as ecotourism, rural tourism, and birdwatching (Martins and Silva 2018; Thapa et al. 2022).

Given its diverse impacts, nature-based tourism can generate both positive outcomes (e.g., increased pro-environmental knowledge, attitudes, and behavior; income generation; and enhanced management ability) and negative effects (e.g., price inflation, environmental degradation, and displacement of local populations). In this context, sustainability indicator systems are essential tools for understanding and evaluating tourisms multiple dimensions (Hanai and Espíndola 2011; Kristjánsdóttir et al. 2018; Miller and Torres-Delgado 2023).

Sustainability indicator frameworks, widely recognized as crucial for evaluating and adopting sustainable policies and practices, play a strategic role in informing decision-making processes (Choi and Sirakaya 2006; Miller 2001; Zhang et al. 2022). These frameworks use systematized datasets to identify, measure, and monitor significant changes in environmental, social, economic, and institutional aspects over time (Tanguay et al. 2013). They generally enable the measurement of progress or setbacks toward sustainable goals.

To achieve sustainable development, it is necessary to adopt integrated indicators that address the economic, environmental, and social dimensions (Kristjánsdóttir et al. 2018). However, one of the primary challenges in producing and collecting data on the sustainability performance of tourism lies in the disparity between these dimensions: while economic data are generally more accessible, current, and reliable, environmental and socio-cultural data often lack these attributes (Modica et al. 2018; Bošković et al. 2020; Miller and Torres-Delgado 2023). This asymmetry highlights the dominance of an economistic logic in tourism development (Miller and Torres-Delgado 2023).

Against this backdrop, increasing attention has been given to the involvement of local communities in the development of sustainability indicators, as their knowledge, values, and perceptions can contribute to more inclusive and holistic assessments that are sensitive to the specificities of local contexts (Simpson 2009; Budruk and Phillips 2011; Han et al. 2023). This participatory perspective relates to the distinction between top-down and bottom-up approaches. According to Sabatier (1986), the top-down approach refers to initiatives led by decision-makers, in which policymakers or those responsible for management practices are the principal actors, without necessarily incorporating other stakeholders' perspectives. In contrast, the bottom-up approach starts by identifying a network of actors involved in the process and emphasizes strategic interactions among multiple stakeholders in shaping actions and management strategies. Applied to the development of sustainability indicators, a bottom-up perspective lets different forms of knowledge and local perceptions inform the identification and selection of aspects to monitor and assess. This approach can therefore support the development of more relevant, contextually appropriate indicators while also contributing to participatory governance and more equitable pathways toward sustainable development (Buarque 2008; Vianna 2008; Snyman 2012; Han et al. 2023).

As Sterling et al. (2017) do, we advocate using biocultural approaches to assess sustainability in nature-based tourism. Grounded in place-based cultural perspectives, these approaches integrate locally specific values, knowledge, practices, and needs, while recognizing the reciprocal relationships between environmental conditions and human well-being (Ster-

ling et al. 2017). Conventional sustainability frameworks, typically structured around environmental, social, and economic dimensions, may overlook the cultural meanings, worldviews, and knowledge systems through which local populations understand and relate to their territories and natural resources. Although participatory methodologies can facilitate local stakeholder involvement, participation does not necessarily mean sustainability assessments incorporate their knowledge, values, and humannature relationships as substantive components. In this sense, a biocultural perspective provides an analytical framework to make these dimensions explicit and identify sustainability aspects that conventional approaches may overlook. In nature-based tourism, this perspective can support the development of more context-sensitive indicators and strategies aligned with local ecological, social, and cultural realities.

Building on the gaps identified in recent literature, this study seeks to address two central questions: (1) How have sustainability indicator systems been developed and applied to measure the sustainability of nature-based tourism activities in Brazil? (2) How do local populations involved in these activities perceive and engage with tourism sustainability? The hypothesis is that measuring tourism sustainability has largely overlooked the social dimension, resulting in indicators that do not adequately reflect the perceptions, concerns, and needs of local and/or traditional populations involved in the activity.

Addressing these questions requires considering both how the scientific literature has operationalized sustainability and how local communities experience and understand sustainability-related issues. Therefore, the study combines a systematic review of the Brazilian literature with an empirical investigation of local perspectives, allowing us to identify gaps in existing indicator approaches and examine them in relation to the study area's socio-environmental context.

Our study is based on three objectives: (1) to investigate how sustainability indicators have been constructed and applied to assess nature-based tourism so far in Brazil, identifying the characteristics of national studies and the main challenges and gaps that exist; (2) to understand how local populations involved in tourism perceive sustainability, considering motivations, visions of the future, perspectives on the concept, current context, and perceptions of costs and benefits; and (3) to propose a set of sustainability indicators based on the contextualization of the issues identified through the literature and local perspectives. By bringing these complementary sources of knowledge together, this approach can be replicated or adapted to other regions with similar socio-environmental conditions.

MATERIAL AND METHODS

Systematic review

We conducted the systematic review between July and December 2023 using the Web of Science, Scopus, and Google Scholar databases. The following combinations of keywords, in both Portuguese and English, were used: "sustainability indicators" + "tourism" and "sustainability indicators" + "tourism" + "Brazil". We selected terms using the approach of Kristjánsdóttir et al. (2018) and Sanches et al. (2018). For article screening and selection, we followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Figure 1), as outlined by Page et al. (2021).

We imposed no restrictions on publication year; we considered only articles published in peer-reviewed journals and excluded conference proceedings, theses, dissertations, and technical reports. We organized the selected studies in electronic spreadsheets and later conducted a full reading for content analysis. From the selected articles, we extracted the following information: (1) year of publication and study location (state and whether conducted in protected areas or not); (2) general objective of the study; (3) methodological approaches employed in the development and application of the indicators; and (4) organization of the indicators (by dimensions environmental, social, economic or otherwise).

The methodological approaches were classified according to Tanguay et al. (2013) into three categories: (1) use of "pre-existing" indicator tables; (2) "creation of new indicator systems"; and (3) "contextualization" of previous work. Additionally, the studies were classified by the approach used to select or develop indicators, distinguishing between top-down and bottom-up approaches, following Sabatier (1986); the classification considered how indicators were defined, selected, adapted, or validated, and the actors involved in these processes. Studies were classified as top-down when researchers, experts, public managers, or decision-makers predominantly defined indicators based on established technical, scientific, or institutional frameworks, with little or no direct involvement of local actors. In contrast, studies were classified as bottom-up when the process incorporated the perspectives, knowledge, demands, or priorities of actors directly involved in the context, such as local communities, residents, workers, civil society organizations, entrepreneurs, or other stakeholders, who participated in the definition, selection, adaptation, or validation of indicators. For the indicator organization, we followed an organizational structure based on the interaction of the main components of sustainable develop-

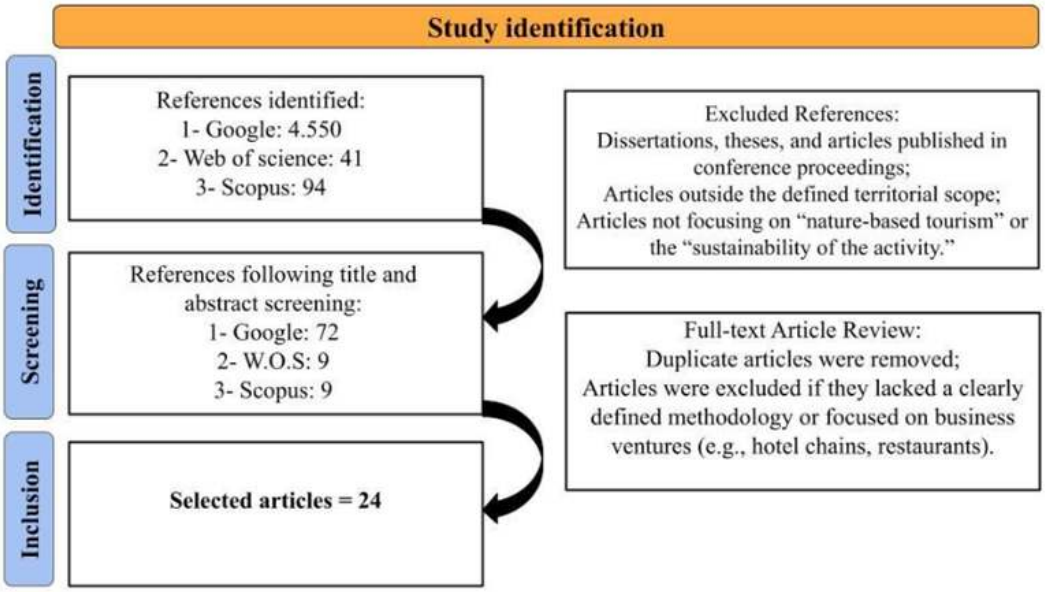

Figure 1. Flowchart of the process of identifying, screening, assessing eligibility, and including studies in the systematic review on sustainability indicators in nature tourism in Brazil, adapted from the PRISMA model.

ment (Beauregard 2003): environmental, social, and economic.

Case Study

Field of Study

The field study was conducted with local people directly involved in nature-based tourism as an economic activity in communities in the municipality of São Desidério, western Bahia. The region is part of one of the country's main agricultural frontiers and is considered a priority area for Cerrado conservation (IPAM 2023), which justifies its selection as a study area. In addition, many local families depend on tourism, driven by natural and cultural attractions such as caves, archaeological sites, rivers with crystal-clear waters, sinkholes, and traditional cuisine.

With a territorial area of 15,158.737 kmš, São Desidério had 32,828 inhabitants in the 2022 Demographic Census, corresponding to a population density of 2.17 inhabitants per kmš (IBGE 2022). Human occupation predates the municipality's political formation, with archaeological evidence indicating Indigenous populations inhabited the Cerrado and practiced hunting, gathering, and the use of local natural resources. Subsequent historical processes contributed to a diverse socio-territorial configuration, including rural and traditional communities and different forms of interaction with and use of natural resources (São Desidério 2023). This diversity provides an important context for understanding the perceptions, experiences, and participation of local actors directly involved in tourism-related economic activities.

By mid-2024, the municipality had two officially established and overlapping Conservation Units: the Lagoa Azul Municipal Park, created by Municipal Decree No. 07/2005, on January 11, 2005 (São Desidério 2005), and the São Desidério Environmental Protection Area (EPA), established by the Government of Bahia State, in June 5, 2006, via Decree 10,020, covering a territorial extent of 10,961 hectares (Bahia 2006). The area includes natural sites such as Lagoa Azul (Blue Lagoon) and Gruta do Catão (Catão Cave) and is used for scientific research, environmental education, and recreation.

In 2024, the territory gained a new protected area: the São Desidério Caves Natural Monument, created by Decree No. 12.042 on June 5, 2024 (Brazil 2024). This protected area covers 16,619 hectares of Cerrado (savanna-like) vegetation and includes a cave complex of high scientific, ecological, and cultural value (ICMBio 2024). The decree sets the following objectives: protecting natural cavities, their associated hydrological systems, and biodiversity; preserving paleontological and archaeological sites; harmonizing land use and natural resource management with conservation goals; and promoting sustainable speleological tourism.

Despite its potential and recent growth, tourism in the region remains small compared with well-established nature tourism destinations in Brazil, such as Chapada Diamantina (state of Bahia), Jalapão (state of Tocantins), and Bonito (state of Mato Grosso do Sul). This underscores the importance of studies aimed at sustainable development of tourism in emerging contexts. The results of such a study can provide valuable insights for areas with similar socio-environmental and institutional characteristics that are developing tourism.

Ethical and legal aspects of research

The Human Research Ethics Committee of the Federal University of Western Bahia approved the research (CAAE 90290918.1.0000.8060). All participants were informed about the study's objectives and procedures and, after voluntarily agreeing to participate, signed the Informed Consent Form.

Data gathering

The inclusion criterion for participant selection was involvement in nature-based tourism activities, regardless of how long they had been operating in this field. We focused on residents who could actively contribute to developing tourism activities. For this reason, we used snowball sampling (Albuquerque et al. 2014). Using this technique, we identified three main groups of stakeholders: (i) tour guides (12 individuals); (ii) owners of private natural attractions (8 individuals); and (iii) owners of lodgings and restaurants (13 individuals).

Data collection aimed to capture local stakeholders' perceptions of tourism sustainability. To achieve this, we conducted semi-structured interviews (Albuquerque et al. 2014), which allow a deep, contextualized understanding of tourism activities, essential for discussing their role in sustainable development and identifying variations in different social actors' perceptions (Additional File 2 and 3). The interviews were organized into two sections:

1st Section Socioeconomic Data: We gathered information on age, gender, education, and income sources to characterize participants' profiles.

2nd Section Contextualization, comprising three thematic blocks: a) motivations and interests in carrying out tourism activities; b) sustainability: participants were invited to share their understanding of sustainability as related to the current state of tourism activities, including perceived costs and benefits; c) future outlook: questions were asked about participants' expectations regarding the future of tourism, priorities for action, and the social actors to be involved.

The information gathered helped select indicators consistent with participants' perceptions, considering the local context and offering a pluralistic approach to sustainability.

Subsequently, a participatory workshop was conducted with interviewees who were also members of the Municipal Tourism Council (COMTUR). Initially, the main findings and the methodological procedures adopted to identify and pre-select the candidate indicators were presented, providing context for their origins and their relationship to local perspectives. Participants then reviewed the indicators to assess their relevance and suitability to the local context. This assessment employed a criterion and scoring matrix adapted from Albuquerque et al. (2014), operationalized through a five-level visual scale: red (strongly disagree), orange (disagree), yellow (neutral), light green (agree), and dark green (strongly agree). The colors were intended to clarify the scale and encourage participants engagement in the assessment process.

During the workshop, participants collectively discussed each indicator and considered its relevance to the municipality's nature-based tourism context. Based on the discussions, participants could retain, reject, modify, or adapt indicators, allowing them to incorporate aspects participants considered relevant and adjust indicators to local specificities. Participants reached agreement through collective discussion and consensus-building. Participants also presented and discussed the procedures for measuring the indicators, including potential data sources, responsible data providers, and data collection frequency. This procedure sought to integrate participatory assessment of the indicators with defining the elements required for future implementation and monitoring. As Islam et al. (2023) noted, involving local actors at this stage can help identify potential respondents and data sources for operationalizing the indicator system.

Data analysis

The interview data, collected to understand the contextual aspects of tourism in the region, were examined through content analysis (Bengtsson 2016). This method systematically organizes empirical material, enabling the identification and interpretation of meanings expressed in participants accounts. Following the four stages proposed by Bengtsson (2016) - decontextualization, recontextualization, categorization, and compilation - we conducted the analysis using NVivo 14 (Lumivero 2023).

We defined analytical categories according to the sustainability triad (economic, social, and environmental). Following Holden (2010), we conducted the analysis interactively and concurrently with field data

collection, allowing continuous critique and refinement of thematic categories. We applied open coding, axial coding, and memo writing, using constant comparison between emerging and pre-identified categories to select the most representative and inclusive ones.

Finally, we quantified how often participants mentioned each category, calculating percentages based on the total number of interview participants (N = 26). Thus, the percentages represent the proportion of participants who mentioned each category.

Characterization of the subjects

The participants comprised a socially and territorially diverse group of local actors whose practices and relationships with the territory reflected different forms of organization and rural livelihoods. Although participants did not necessarily self-identify as members of traditional communities or culturally differentiated groups, the study documented accounts and practices that exhibited characteristics associated with Geraizeira communities, riverine communities, and rural or local populations. These characteristics included using and managing Cerrado resources, agro-extractive practices, free-range cattle raising, family farming, and other agricultural activities. Participants living near rivers reported daily relationships with aquatic environments and their resources. In contrast, those in rural areas reported relationships more directly connected to land, vegetation, and local landscapes for agricultural production.

Participants ranged in age from 25 to 80 years. Regarding gender, 65.4% identified themselves as men and 34.6% as women. The most common education level was high school (38.5%), followed by elementary school (27%), incomplete elementary school (11.5%), undergraduate degree (11.5%), complete or ongoing graduate studies (7.5%), and ongoing undergraduate degree (4%). Only 30% reported having tourism as their only source of income; the others (70%) also worked with livestock, family farming, real estate brokerage, and general services. Tourism activity was seasonal, with higher demand during the dry season, holidays, and vacations, and lower intensity during the rainy season.

RESULTS AND DISCUSSION

Systematic review: sustainability indicators in the context of nature-based tourism

The selection included 24 articles on sustainability indicators used to assess nature-based tourism in Brazil (Additional File 1). The earliest study dates to 2006, indicating that the topic has attracted academic attention only in recent decades. The identified approaches to nature-based tourism included rural tourism, Indigenous tourism, Quilombola tourism, ecotourism, geotourism, nature tourism, and bird-watching.

Geographically, Minas Gerais and Paraíba were the most frequently studied states. Regarding environmental protection status, 46% of the studies were conducted outside protected areas, 46% within Conservation Units (CUs), and 8% in Indigenous and Quilombola Territories. We classified as mixed those cases in which the attractions analyzed were located both inside and outside protected areas (Figure 2a, b).

Most studies (58.3%) developed indicator frameworks based on pre-existing structures (Figure 2c), such as: (1) the criteria established by Bonfato et al. (2019); (2) the methodology for hierarchizing tourist attractions from the Tourism Regionalization Program of Brazil - CICATUR (Brazil 2004); (3) the framework developed by Faxina (2014); (4) the methodology proposed by Pires (2005); (5) the SIDSTUR developed by Hanai (2009); and (6) the World Tourism Organization framework (UNWTO 2004). These references encompass both globally and nationally designed indicators. In 33.3% of the studies, pre-existing structures were adapted to local contexts using methodologies such as: (1) bibliographic surveys; (2) the PressureStateResponse (PSR) or PressureStateImpactResponse (PSIR) models, which follow a cyclical concept of causality to explain relationships between human activities and the environment; (3) indicators developed by the Brazilian Institute of Geography and Statistics (IBGE), covering environmental, social, economic, and institutional aspects; and (4) the Visitor Impact Management (VIM) framework, which focuses on visitor-related impacts and strategies to manage their activities and effects on specific areas; only 8.3% of studies created entirely new indicator frameworks based on bibliographic reviews and expert consultation.

This scenario contrasts with global trends, where contextualization is more common (Kristjánsdóttir et al. 2018). This approach tends to yield better results than directly applying existing frameworks, as it incorporates local realities into indicator selection and ensures greater adaptability (Kristjánsdóttir et al. 2018). The Convention on Biological Diversity (CBD 2015) guidelines reinforce this perspective, emphasizing that tourism planning should be guided by specific goals and objectives collectively agreed upon by all stakeholders.

Methodologically, 79% of studies adopted a top-down model, while only 21% used a bottom-up ap-

proach (Figure 2c). This reflects the low adoption of participatory methodologies, despite the acknowledged importance of goals for assessing tourism sustainability that all stakeholders understand and agree on (Leung et al. 2018).

Studies classified as adopting a bottom-up approach reported different forms of community involvement in 21% of cases. These included the adaptation of indicator frameworks through community workshops to identify demands related to quality of life and natural resources (Faxina et al. 2021); participatory workshops with Advisory Management Councils to identify relevant topics concerning tourism impacts and to strengthen local understanding and decision-making (Sancho-Pivoto et al. 2020); the use of adapted quantitative questionnaires to assess the impacts of tourism on Indigenous communities (Brandão et al. 2015); the identification of sustainability indicators through observation, interviews with local entrepreneurs, and questionnaires administered to tourists (Ferreira et al. 2019); and the development of a database based on visits and conversations with families engaged in tourism activities, which supported the use of indicators to identify local tourism identity and evaluate tourist attractions (Moraes et al. 2013).

Using Pretty's (1995) scale, most of these cases fall under consultative participation, in which the community is heard through consultations, but external agents define the problems and processes. Only the study by Moraes et al. (2013) was classified as functional participation, with shared decision-making. In that case, local entrepreneurs followed methodological procedures and adjusted the definitions and descriptions of parameters and indicators at various stages.

Participation can range from manipulative participation, where people are merely informed and assigned predetermined roles, to self-mobilization, in which local populations autonomously initiate and carry out decisions independent of external actors (Pretty 1995). To move along this spectrum, institutions and individuals must shift from hierarchical models, such as consultative participation, toward more interactive forms that ultimately enable self-mobilization. Without developing skills, interests, and capacities, local communities tend to lose interest in maintaining participatory structures and practices (Pretty 1995).

Neglecting diverse perspectives on non-human life, needs, and worldviews, often justified by claims of scientific objectivity or universalism, undermines the legitimacy and social effectiveness of conservation actions. Groups with differing values and interests are more likely to contest or reject such actions (Pascual et al. 2021). A pluralistic approach is therefore essential, recognizing each actor or social groups interpretations and values. As proposed for biodiversity (Pascual et al. 2021), the same principle should apply to sustainability, acknowledging the multiple motivations behind peoples concerns. This involves amplifying a constellation of voices, especially from local, traditional, and indigenous communities whose livelihoods often depend directly on nature. Building this perspective requires recognizing differences in what should be governed or managed and in conservation objectives, and centering the debate on what people and groups want to include in decision-making.

Research in nature tourism destinations in South Korea indicates that residents support for sustainability is linked to their perceptions of tourism impacts (Han et al. 2023). A comprehensive assessment of these impacts is crucial, as tourism can significantly influence both overall life satisfaction and perceptions of tourism development. This understanding is vital to increase local involvement in tourism planning and management and support more sustainable practices. To foster this engagement, strategic tourism planning must address tourism's economic, socio-cultural, and environmental impacts on residents (Han et al. 2023).

Finally, studies most often used thematic classification of indicators by dimension (Figure 2d), aligning with global patterns (Kristjánsdóttir et al. 2018) and demonstrating its broad acceptance. While these findings highlight the equal importance of economic, environmental, and social pillars for sustainable development, they can also imply that these spheres are independent and lack interconnections (Miller and Twining-Ward 2005). Thus, indicators must support a comprehensive, integrated analysis of sustainability dimensions by considering both internal and external system impacts, grounded in technical and scientific methods, and incorporating multiple stakeholder perspectives (Castellani and Sala 2010; Tanguay et al. 2013; Kristjánsdóttir et al. 2018).

Some studies employ different nomenclatures for the dimensions, such as natural or ecological, both of which are incorporated here into the environmental dimension; human system, classified within the social dimension; or more specific subdivisions, such as conservation unit, water, forest, culture, living space, and production associated with tourism and hospitality, which are categorized in this analysis across the social, economic, and environmental dimensions.

Most studies (78.47%) adopted indicators in an integrated manner, addressing all three dimensions of sustainability simultaneously, whereas 21.53% used them in isolation. Studies that view tourism as part of a complex socio-ecological system support the integrated approach, requiring a joint assessment of environmental, economic, and social conditions to guide decisions aimed at sustainable development (Castellani and Sala 2010; Tanguay et al. 2013; Kristjánsdót-

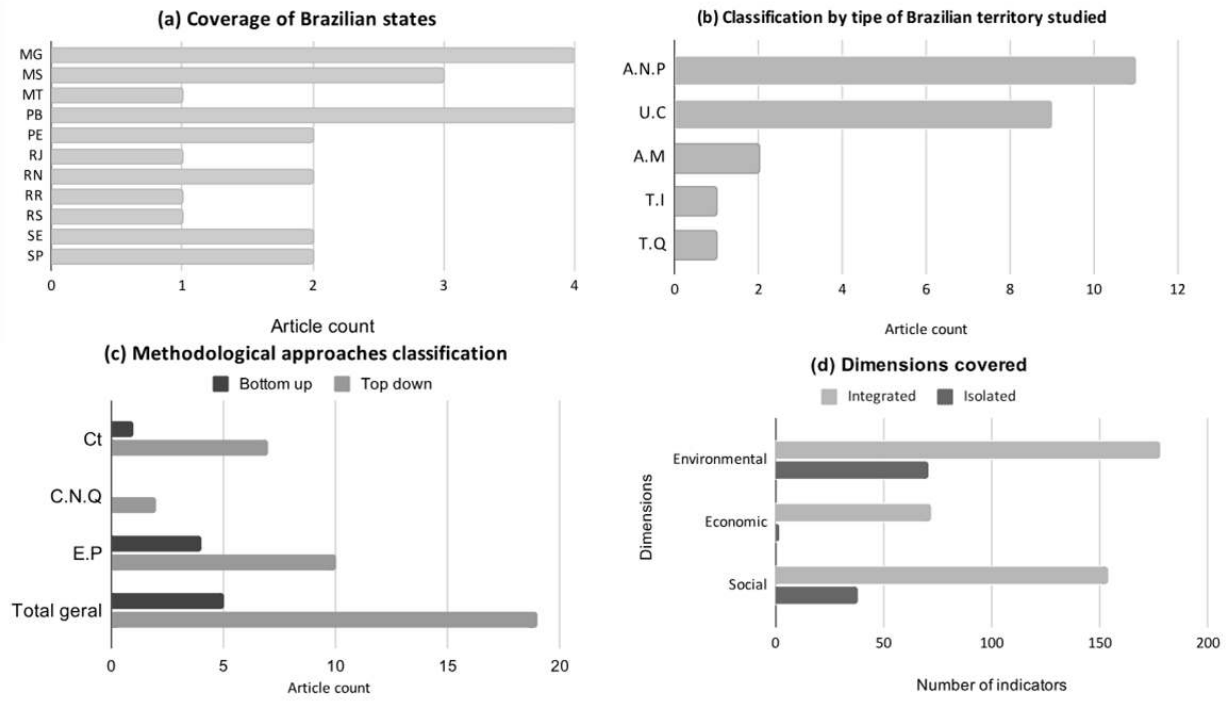

Figure 2. Overview of the information extracted from the selected articles, including: (a) geographic coverage (MG=Minas Gerais; MS=Mato Grosso do Sul; MT= Mato Grosso; PB= Paraíba; PE= Pernambuco; RJ=Rio de Janeiro; RN= Rio Grande do Norte; RR=Roraima; RS= Rio Grande do Sul; SE= Sergipe; SP=São Paulo); (b) type of territory (A.N.P = Non-Protected Areas; U.C = Conservation Unit; A.M= Mixed areas; T.I = Indigenous Territory; T.Q = Quilombola Territory); (c) methodological approaches used (C.C. = Contextualization, C.N.Q = Construction of New Frameworks, E.P = Pre-existing Structures); (d) types of dimensions addressed.

tir et al. 2018).

Tourism requires effective assessment tools for both planning and management (Miller and Torres-Delgado 2023). In this review, we found that integrated approaches predominate; however, the results also highlight the limited inclusion of community-based research, which weakens the social dimension. Social participation is a key element in developing integrated indicators, as it helps decision-makers evaluate tourism's multifaceted role within complex socio-ecological systems and fosters a deeper understanding of long-term challenges and opportunities (Kristjánsdóttir et al. 2018).

Case study: A biocultural approach to tourism evaluation in western Bahia

Understanding the local perception of sustainability in tourism

We conducted 26 interviews with attraction owners, innkeepers, and restaurant owners at tourism sites, as well as with tour drivers at the Federal Institute of Bahia (IFBA) campus in São Desidério. Although researchers initially identified 33 potential participants, they interviewed only 26 due to logistical constraints. These participants constituted the final sample for the interview analyses. The geographical dispersion of tourism sites and the seasonality of activities affected stakeholder availability; however, data saturation was reached, as recurring themes and perceptions emerged consistently after a certain point.

Natural wealth was the primary motivation for tourism (39%; Table 1), with landscapes valued for both contemplative enjoyment and adventure sports.

This emphasis on the environmental dimension was mirrored in participants understanding of sustainability (39%; Table 2). Social and economic aspects complemented environmental concerns, reflecting a holistic perspective that integrates economic development, social empowerment, and environmental conservation. For the interviewees, preserving the natural environment is essential to tourism's long-term viability, consistent with the systematic review, which also identified the environmental dimension as predominant in tourism sustainability debates.

Silva et al. (2011) reported similar results in a study conducted in Porto de Galinhas (Pernambuco) that examined social inclusion in tourism through the principles of the solidarity economy. The authors emphasized protecting natural resources as a prerequisite for tourism's continuity, but cautioned that environmental concerns should not be limited to tourism's interests.

Participants also addressed the perceived benefits and costs of tourism (Table 3). Participants cited income as the most frequent benefit (96%), while environmental degradation was the most relevant cost (73%). The literature suggests that people often perceive benefits at the individual level, while they experience costs collectively (Thapa et al. 2022). Notably, most environmental risks mentioned were linked to external factors, such as monoculture expansion and the construction of Small Hydroelectric Power Plants (SHPs). By contrast, participants largely perceived tourism not as a direct threat but as an activity that could coexist with environmental conservation if managed effectively.

Thapa et al. (2022) highlighted that the benefits of nature-based tourism for local populations must extend beyond financial aspects and encompass multiple livelihood dimensions, such as cultural support, biodiversity conservation, and infrastructure. In the present study, some of these positive aspects were mentioned, including environmental awareness (15%), conservation (50%), infrastructure (15%), dialogue (23%), and sense of belonging (8%), but at a much lower frequency than income (96

These results reveal a gap in promoting more inclusive tourism, a finding Silva et al. (2011) also reported. The systematic review found low community participation in the studies analyzed. At the same time, field data showed that local informants value individual economic benefits more than collective ones. At the same time, field data showed that local informants value individual economic benefits more than collective ones. Participatory biodiversity monitoring initiatives in Brazil likewise identify direct payment as the main motivation for monitors, framing it as an individual benefit (Tófoli et al. 2019). In a related context, Tófoli et al. (2019) found that individual financial incentives may compromise the long-term sustainability of such activities, highlighting the importance of distributing benefits collectively and across economic, social, and environmental dimensions. Therefore, it is necessary to rethink the tourism development model, prioritize inclusion, equity, and social transformation, and move beyond an exclusively conventional economic logic (Silva et al. 2011). Leung et al. (2018) reinforce this perspective, emphasizing the importance of local capacity building and identifying barriers to collaboration for sustainable management in protected areas.

In addition to the classic dimensions (economic, social, and environmental), participants highlighted the governance dimension (Table 3), corroborating other studies that recognize its central role in management legitimacy and effectiveness (Gutierrez et al. 2020).

Regarding perspectives, most respondents anticipated an expansion of activities (79%), followed by maintaining the current status (19%), while others expressed no clear perspective (4%). As noted in other studies forecasting tourism growth (Gutierrez et al. 2020; Leung et al. 2018), most local actors consulted here also expressed this expectation. Within this expansion scenario, network growth stood out, involving increased availability of local products and activities, as well as greater promotion of attractions and festivities. Studies on participatory biodiversity monitoring similarly suggest building institutional and community networks as key management tools (Tófoli et al. 2019).

Accordingly, the actions to be undertaken were grouped into three categories: maintain (initiatives already underway that should be continued), improve (those requiring enhancement or reinforcement), and implement (new initiatives to be developed) (Table 4). The most prominent implement actions suggested by participants were: tourism-focused governance, stakeholder cohesion, and outreach. According to Leung et al. (2018), partnerships in which all stakeholders actively participate in planning are essential for sustainable tourism. The authors stress that public engagement, combined with effective communication, is crucial to designing, implementing, and monitoring actions.

Participants cited several actors as stakeholders in tourism management, emphasizing the Municipal Environment Secretariat (53.8%) and the local population in general (46.15%), including individuals not directly involved in tourism activities. State and federal environmental agencies (30.7%), such as the Institute of Environment and Water Resources (INEMA); private sector companies that use natural resources (30.7%), including environmental consultancies, companies linked to agribusiness, and Small Hydropower

Plants (SHP); and educational institutions (26.9%), such as schools and universities, were also mentioned. In this context, it is essential to consider the motivations and needs of these different social actors in

Table 1. Motivations and interests pointed out by participants for carrying out tourist activities in the municipality of São Desidério, Bahia.

Motivations	Quotes from interviewees speech	Frequency
Natural wealth	"Potential, primarily local, the rich landscapes, diversity of fauna and flora, possibility to carry out many adventure activities"; "the natural riches, caves, grottoes, speleothems, the desire to know and disseminate".	39%
Sociocultural aspects	"I saw that it was a way to cover the whole community, the people who like to cook, those who make handicrafts, and those who like to walk through the different landscapes and present them"; "We travel a lot, and we saw that here there is great potential, the strength of the region and its gastronomy".	19%
Economic aspects	"Source of income, it was a way to explore my area"; "need for financial autonomy, and to have more tranquility"; "I knew the potential that the activity had, that it would receive a return, and that it would be in demand."	19%
External demand	"We were kind of forced; people started to come and call other people, and then we were receiving and preparing to receive"; "People valued that area very much, they wanted to visit, get to know it, schools came, they really liked to hear our stories."	23%

Legend: Percentages represent the proportion of participants who mentioned each category, based on the total number of interview participants (N = 26).

Table 2. Perspectives on the concept of sustainability according to members of the local population involved with tourism in São Desidério, Bahia.

Dimension addressed	Quotes from interviewees speech	Frequency
Environmental	"always take care of the environment, a matter of nature"; "seek to maintain preservation, not to attack"; "The presence of man alone is degrading, but sustainability and degrading the minimum to maintain the maximum, preserve, keep clean, reforest..."; " sustainability is enjoying without destroying".	39%
Socio-environmental	"Maintain nature, also valuing people and cuisine"; "It is a practice; they start from actions that aim to minimize negative impacts on the environment, part of the practice of citizens; it is interconnected with health in all senses in the long term".	11,5%
Feasible (environmental + and economical)	"Sustainability is any activity that does not degrade the environment, that you can maintain (financially) in a way that is durable."	11,5%
Integrated	"Sustainability is when you can get money without destroying and degrading natural resources. Thinking about the social, we could do community-based tourism to get to know the cultural riches, our handicrafts"; "Sustainability is living remembering that another will come after you"	23%
Don't know	The person stated that they were unaware of the term.	15%

Legend: Percentages represent the proportion of participants who mentioned each category, based on the total number of interview participants (N = 26).

management processes. Although this can make the system more complex, it tends to generate decisions better adapted to socio-environmental contexts (Tófoli et al. 2019).

Choice of indicators based on local perspectives

We selected the indicators based on the most prominent issues identified through semi-structured interviews conducted in our case study in Western Bahia (Section 3.2.1). Initially, the researchers systematically organized and categorized the interview data by the main themes, problems, perceptions, and demands participants reported. This categorization guided the researchers in defining four thematic dimensions that structured the indicator selection process: biocultural conservation, tourism seasonality, engagement and information, and local perspectives.

1. Biocultural conservation: Addressing the environmental dimension, this section groups both measurable and perceptual indicators related to themes such as environmental degradation, river revitalization, and inspection of attractions. We selected both measurable and perceptual indicators, emphasizing the importance of including local and tourist perceptions to assess the effectiveness of these actions.

2. Seasonality of activity: This section includes economic indicators. Participants identified seasonality as a main challenge. Because participants see individual income as the primary benefit, along with concerns about low remuneration, we selected indicators to measure this issue. The aim is to support strategies for a fairer and more resilient local economy.

3. Engagement and information: Related to governance, this section proposes indicators to measure the communitys level of participation and perceptions of tourism initiatives, including transparency and communication effectiveness. These indicators were selected to identify pathways toward tourism-focused governance and effective outreach strategies.

4. Local perspectives: Focused on the social dimension, this section includes indicators that capture residents perceptions of cohesion among actors, appreciation of local products, and tourism's impacts. As Leung et al. (2018) note, community support is essential to the stability and sustainability of tourism activities.

Using this thematic and contextual framework, the researchers mapped issues emerging from the interviews to the indicators in Indicators of Sustainable Development for Tourism Destinations: A Guidebook (UNWTO 2004). At this stage, the researchers assessed the relevance of the proposed indicators in relation to the four thematic dimensions defined from the empirical data, considering both the nature of the issues identified and their applicability to the local context. This process yielded 16 candidate indicators aligned with the issues emerging from the interviews and relevant to the local context. Thus, we did not apply the indicators in their entirety or transpose them directly from the guide; instead, we used the guide as

Table 3. Benefits and costs of nature tourism according to the perceptions of participants in the research carried out in São Desidério, Bahia.

Dimension	Benefits cited	Frequency	Cited costs	Frequency
Environmental	Environmental awareness	15%	Environmental degradation	73%
	Conservation	50%		
Governance	Dialogue	23%	Centralization	30%
Economic	Employment	23%	Low pay	30%
	Infrastructure	15%		
	Income	96%		
Social	Leisure	14%	Gentrification	8%
	Belonging	8%	Public insecurity	15%
	Valuing the Municipality	42%	Migration	8%
			Cultural Loss	8%

Legend: Percentages represent the proportion of participants who mentioned each category, based on the total number of interview participants (N = 26). Participants could mention multiple categories.

a reference framework for identifying potentially applicable indicators.

The guide includes more than 700 indicators addressing different tourism sustainability issues, organized by thematic areas and specific destination applications. This was one reason for selecting the guide, along with its criteria for assessing indicators, including relevance, feasibility, credibility, clarity, and comparability. To avoid indiscriminate selection from this broad pool, we conducted an initial screening based on issues empirically identified through the interviews and the sections of the guide most relevant to the study context. In Part 4 of the guide, which focuses on applications across different types of destinations, we gave particular consideration to sections addressing natural and ecologically sensitive areas, ecotourism destinations, parks and protected areas, communities within or adjacent to protected areas, small and traditional communities, and communities seeking to develop tourism. This procedure narrowed the guides initial pool to the issues and application contexts most closely aligned with São Desidério's environmental, social, and tourism characteristics.

In the next stage, participants reviewed the 16 candidate indicators during the participatory workshop using a criterion and scoring matrix (Figure 3), which also facilitated discussion of implementation strategies and community-based monitoring. The discussions also enabled participants to assess the indicators' suitability in relation to issues and experiences encountered in the local context, and to identify aspects that could be adjusted in their formulation and application. Thus, local participation not only validated the indicators the researchers had previously selected but also helped refine and adapt them to the sociocultural and territorial specificities of São Desidério.

The workshop resulted in strong agreement with the 16 proposed indicators, which were retained as the final set, with adaptations based on participants discussions and contributions (see Additional File 4). The workshop also highlighted specific cultural and territorial issues, broadening understanding of aspects to consider when assessing tourism-related changes and prioritizing subjective indicators to support a

Table 4. Actions suggested by the local population involved in tourism in São Desidério, Bahia, categorized by perspective.

Classification	Actions	Frequency	Dimension
Maintain	Professional courses	4%	Social
	Aesthetics of the environments	4%	Environmental
	Local hospitality	4%	Social
	Municipal tourism plan	19%	Governance
	Preservation actions	8%	Environmental
	Conservation Units	31% E	nvironmental
Improve	Creation of protected areas	34,5%	Environmental
	Infrastructure	46%	Economic
Do	Cohesion among stakeholders	77%	Social
	Disclosure	61,5%	Governance
	Environmental education	54%	Environmental
	Surveillance	38%	Environmental
	Strengthening local products	27%	Social
	Governance focused on tourism	81%	Governance
	Revitalization of the river	46%	Environmental

Legend: Percentages represent the proportion of participants who mentioned each category, based on the total number of interview participants (N = 26). Participants could mention multiple categories.

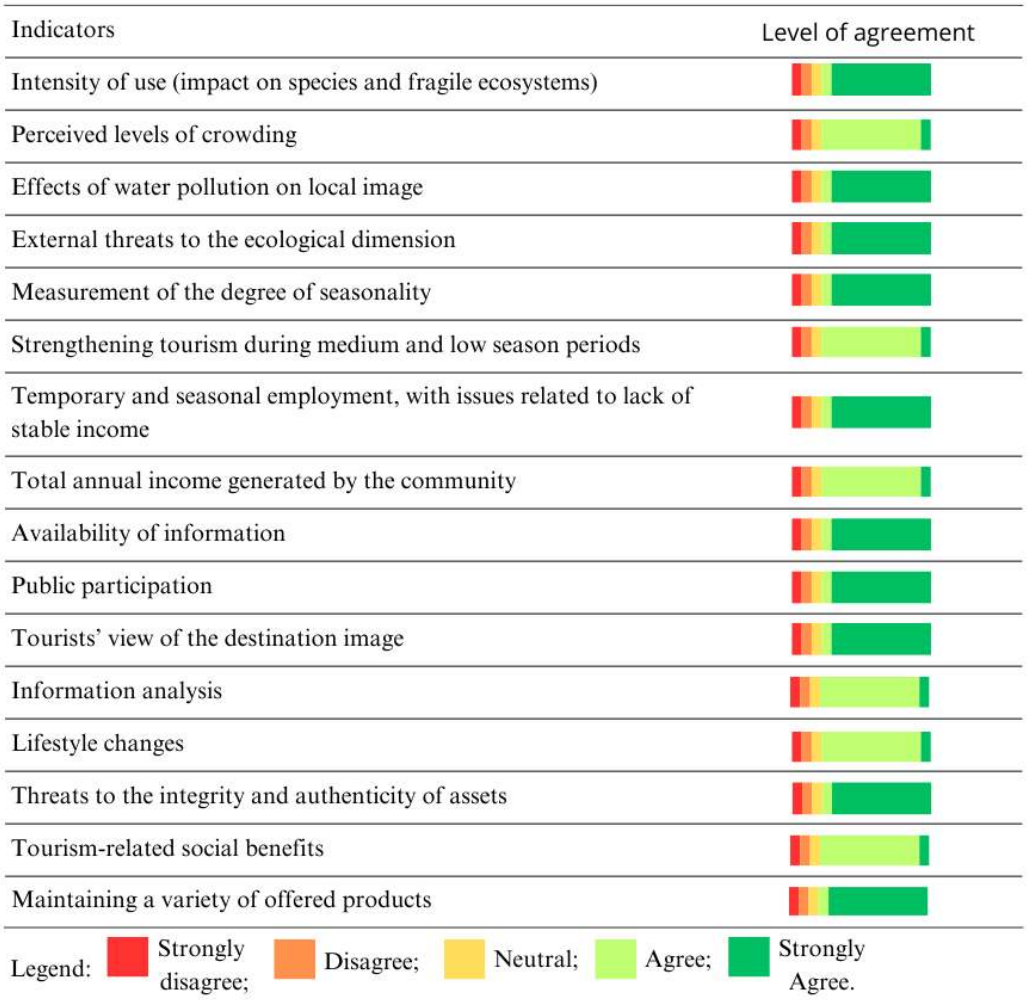

Figure 3. Level of agreement with the tourism sustainability indicators, selected from a biocultural approach, obtained during a workshop with the members of the Municipal Tourism Council of São Desidério, Bahia.

monitoring system residents could implement, incorporating their perceptions and knowledge of tourism-related transformations. This approach aligns with the literature emphasizing the importance of accounting for local specificities and the complementarity between qualitative and quantitative data in developing sustainability indicator systems (Morse et al. 2001; Gutierrez et al. 2020).

During the participatory validation stage, discussions by thematic dimension provided important input for refining the initial proposals and revealed aspects sensitive to local reality. In the environmental dimension, the integration between ecological data (e.g., intensity of use of the attractions) and perception data on fauna, flora, and abiotic components (e.g., water quality of the rivers) was identified as a priority, especially in Lagoa Azul Municipal Park (where ecological surveys have already been conducted) and other natural areas of tourist interest.

In the economic dimension, the study highlighted the difficulty of obtaining direct data on tourism-generated income, given residents' fear of sharing this information. Participants suggested that community members collect the data to build trust and encourage compliance. They also recommended using percentages rather than absolute values to preserve confidentiality while still generating useful data. They also emphasized integrating the tourist calendar with local cultural and religious festivities to increase visitor flow during the low season and stimulate a more continuous and inclusive economy.

In the governance dimension, participants noted

less local engagement in participatory processes, saying community participation had previously been stronger. In this sense, they highlighted the potential of associative actions to reverse this trend by promoting stronger community organization and participation in tourism-related decisions. They also noted the lack of systematized information. They proposed creating a local information center that brings together data on tourist attractions, accommodation, and food establishments, including prices, opening hours, and days. They saw such an instrument as fundamental to facilitating access to updated, reliable information for local community members and tourists.

In the social dimension, concerns about local cultural erosion emerged, expressed in statements such as "culture is being lost over time." This highlighted the need to include indicators that assess the transmission of traditional knowledge and lifestyle changes as ways to measure the continuity of cultural practices. Reports about the extinction of traditional cultural events, such as the "lamentation of souls," reinforced the desire for tourism to also function as an instrument of cultural appreciation and revitalization.

In light of these contributions, the final set of indicators incorporated dimensions that emerged from local experiences and perceptions and may remain insufficiently captured by conventional sustainability indicator frameworks. The system incorporated indicators selected and adapted during the workshop to capture changes in lifestyles, the availability and transmission of knowledge, the maintenance of cultural practices and events, the social benefits of tourism, and transformations in peoples relationships with the territory. These elements broaden the assessment of sustainability beyond measuring environmental conditions or isolated socioeconomic aspects, allowing consideration of interdependencies among biodiversity, local knowledge, cultural practices, territorial relationships, livelihoods, and well-being. In this sense, the proposed indicators provide a tool for assessing different dimensions of nature-based tourism sustainability while also creating opportunities to incorporate local knowledge and perceptions into tourism management and decision-making.

CONCLUSION

The systematic review found that most studies adopt an integrated approach, considering the different dimensions of sustainability together. This is positive, as it allows us to evaluate tourism's multifaceted role in complex socio-ecological systems and contributes to a more comprehensive understanding of the activity's long-term challenges and opportunities. However, we also identified an important gap: community-based research remains underrepresented in both the literature and practice, as our field study also shows. This limitation is particularly relevant to the social dimension, since active participation by local communities is fundamental to the effective management of natural areas and the development of truly sustainable processes.

By integrating the results of the review with the data collected in the field, we highlight some relevant points of complementarity: 1) the centrality of the environmental dimension, identified as the most recurrent and, at the same time, the most mentioned by the local community, both as a motivation for tourism and as a central element in understanding the concept of sustainability; 2) the predominance of top-down approaches in Brazilian studies, in connection with participants reports of limited involvement in local decision-making processes, which reinforces the need for participatory methodologies and the incorporation of biocultural indicators that are more sensitive to local specificities.

Given the expected growth in tourism activity in the coming years, a scenario widely mentioned by survey participants for the São Desidério region, it is even more urgent to develop strategies that ensure the equitable distribution of the benefits generated. Our study contributes to these efforts by broadening understanding of the concepts and practices associated with tourism sustainability, especially from the perspectives of the local community directly involved in the activity. Participatory development of a sustainability indicator system makes it possible to identify priority issues to monitor, helping guide tourism development in the region toward a fairer, more inclusive, and sustainable model. In addition, the results presented here can strengthen dialogue between local experiences and global discussions on sustainable tourism, highlighting the importance of preserving local narratives and epistemologies to counter reductionist approaches that often shape decision-making.

Finally, this study identified and proposed a set of indicators based on a biocultural approach to nature tourism in the municipality of São Desidério. We recommend that future studies advance in the implementation and empirical evaluation of these indicators to verify their applicability and effectiveness in practice. We also reinforce the importance of continuously evaluating the perceptions and attitudes of the different actors involved, especially in contexts of rapid socio-environmental transformation. Because our study focused on the perceptions of local actors directly involved in tourism, future research should broaden this scope to include other stakeholders, such as tourists and public and private managers of the activity.

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DATA AVAILABILITY

Because local communities participated and due to confidentiality concerns, and in accordance with the Human Research Ethics Committee of the Federal University of Western Bahia, the raw data are not publicly available. Nevertheless, they may be obtained from the corresponding author upon reasonable request, subject to approval by the Human Research Ethics Committee.

CONFLICT OF INTEREST

The authors declare no competing interests.

CONTRIBUTION STATEMENT

Conceived of the presented idea: Wallas Gabriel dos Santos Calazans; Ângelo Giuseppe Chaves Alves. Carried out the experiment: Wallas Gabriel dos Santos Calazans; Letícia Zenóbia de Oliveira Campos; Taline Cristina da Silva; Ângelo Giuseppe Chaves Alves. Carried out the data analysis: Wallas Gabriel dos Santos Calazans; Letícia Zenóbia de Oliveira Campos; Taline Cristina da Silva; Ângelo Giuseppe Chaves Alves. Wrote the first draft of the manuscript: Wallas Gabriel dos Santos Calazans. Reviewed and finalized the manuscript: Wallas Gabriel dos Santos Calazans; Letícia Zenóbia de Oliveira Campos; Taline Cristina da Silva; Anna Karolina Martins Borges; Ângelo Giuseppe Chaves Alves. Supervision: Letícia Zenóbia de Oliveira Campos; Taline Cristina da Silva; Anna Karolina Martins Borges; Ângelo Giuseppe Chaves Alves.

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DISCLOSURE OF AI USE

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) and Grammarly to assist with language editing and revision of the English text. The authors reviewed and edited all content after using these tools and take full responsibility for the publication's content.

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Additional Files

Add File 1. Reference framework of the studies selected in the systematic review.

Título	State	T.D ou B.U	System used	Citation
Observação de aves e ecoturismo em Itamaracá (PE): instrumentos para o desenvolvimento sustentável	PE	T.D	OMT	Farias, et al. (2006).
Políticas públicas de turismo e indicadores de sustentabilidade ambiental: um estudo sobre Bonito - MS	MS	T.D	PER	Trentin. e Sansolo (2006)
Avaliação preliminar do potencial turístico do município de Rifaina (SP) e os impactos decorrentes do uso público de seus atrativos paisagísticos	SP	T.D	VIM (Visitor Impact Management)	Zanfelice et al. (2009)
Indicadores para o Desenvolvimento Sustentável do Turismo de Base Comunitária: Um Estudo de Caso da Comunidade do Quilombo do Campinho da Independência, Paraty, Rio de Janeiro.	RJ	T.D	IBGE	Pinheiro (2013)
Análise de paisagens turísticas da praia de touros/RN com a utilização de indicadores de qualidade visual: uma contribuição para o turismo sustentável	RN	T.D	Pires (2005)	Medeiros et al. (2013)
Indicators for the identity of the community-based tourism on Serra do Brigadeiro territory (MG, Brazil)	MG	T.D	CICATUR (2005)	Moraes e Ribeiro (2013)
Ensaio de uma metodologia com indicadores para o turismo de base comunitária: O caso do Território da Serra do Brigadeiro Brasil	MG	B.U	CICATUR (2005)	Moraes et al. (2013)
Análise de paisagens turísticas da praia de ponta negra (Natal/RN) com a utilização de indicadores de qualidade visual: uma contribuição para o turismo sustentável	RN	T.D	Pires (2005)	Soares et al. (2014)
Desenvolvimento de indicadores de sustentabilidade para o Ecoturismo em Unidades de Conservação	-	T.D	Consulta a especialistas	Filetto e Macedo (2015)
A relação entre a tipologia de governança e o nível de sustentabilidade no destino turístico do Conde PB	PB	T.D	SIDSTUR	Cantalice e Cândido (2015)
Análise da sustentabilidade do turismo: um estudo em comunidades indígenas no Estado de Roraima, Brasil	RR	B.U	OMT	Brandão et al. (2015)
Sistema de indicadores de sustentabilidade do desenvolvimento do turismo: um estudo de caso do município de Areia - PB	PB	T.D	SIDSTUR	Silva e Cândido (2016)
Impactos do geoturismo nos atrativos naturais das águas do polo turístico das águas de São Lourenço, MT.	MT	T.D	VIM - PER	Godoy et al. (2017)

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Título	State	T.D ou B.U	System used	Citation
Tourism activities and sustainability indicators: a study in a brazilian tourist destiny	PE	T.D	SIDSTUR	Santos e Cândido (2018)
O turismo de base comunitária como perspectiva para a preservação da biodiversidade e aspectos culturais da Serra dos Alves, Itabira (MG)	MG	B.U	OMT	Ferreira et al. (2019)
Indicadores de sustentabilidade para o turismo sustentável: um estudo no município de Bananeiras (PB)	PB	T.D	SIDSTUR	Nunes e Martins (2019)
Indicadores de sustentabilidade e a gestão do turismo: uma proposta para o Parque Estadual Marinho de Areia Vermelha Paraíba - Brasil	PB	T.D	PEIR	Silva et al. (2020)
Aplicação de indicadores do turismo sustentável em um balneário em área de cerrado no município de Coxim-MS	MS	T.D	Levantamento Bibliográfico	Santos et al. (2020)
Sustentabilidade social do turismo no município de Machadinho-RS	RS	T.D	SIDSTUR	Lacerda e Mecca (2020)
Efeitos e transformações gerados pelo turismo no contexto territorial do parque estadual do Ibitipoca, Minas Gerais, Brasil	MG	B.U	Levantamento bibliogáfico	Sancho-Pivoto et al. (2020)
Percepção sobre indicadores tecnológicos, sustentáveis e ambientais do turismo fluvial do baixo são Francisco/SE	SE	T.D	PEIR	Santos et al. (2020)
Environmental sustainability in fishing communities within tourist destinations: the case of Mem de Sá Island-Brazil	SE	B.U	Faxina (2014)	Faxina et al. (2021)
Sustainability Index of the Gruta do Lago Azul Natural Monument, Bonito Mato Grosso do Sul, Brazil	MS	T.D	Criação própria	Silva-Melo et al. (2021)
Proposta para fazer da Brotas, Brasil, um destino turístico inteligente	SP	T.D	Bonfato et al. (2019)	Bonfato et al. (2022)

* T.D = Top-down; B.U = Bottom-up.

Add File 2. Sociodemographic Questionnaire.

Code: _____ **Date:** _____ **Location:** _____

1. **Participants Name:** _____
2. **Age:** _____
3. **Gender:** Female ☐ Male ☐ Other ☐
4. **Level of Education:**
   ☐ Incomplete primary education
   ☐ Complete primary education
   ☐ Complete secondary education
   ☐ Incomplete higher education
   ☐ Complete higher education
   ☐ Postgraduate studies (completed or in progress)
5. **Current Sources of Income:**
   _____
6. **Please list the economic activities in order of their contribution to your total income, indicating the approximate percentage of income derived from each activity, as well as the corresponding period or seasonality:**
   ☐ _____, _____%, _____
   ☐ _____, _____%, _____
   ☐ _____, _____%, _____
   ☐ Other. Please specify: _____
7. **Do you participate in any social organization? Please select all applicable options:**
   ☐ I do not participate in any organization. Please explain:
   _____
   ☐ Cooperative. Please specify:
   _____
   ☐ Association. Please specify:
   _____
   ☐ Other. Please specify: _____

12.a) To what extent do you feel included and adequately heard within these organizations?
_____

13. **Would you like to receive the results of this study via email or WhatsApp?**
    ☐ Yes. Please provide your contact information: _____
    ☐ No

Interviewer: Please use the space below to record any comments or clarifications regarding the responses provided.

Add File 3. Interview Guide (for interviewer use)

Code: _____ **Date:** _____ **Location:** _____

Interviewer Introduction

Hello, my name is Wallas Gabriel dos Santos Calazans. I am a researcher at the Federal Rural University of Pernambuco (UFRPE), and I am conducting interviews with individuals engaged in tourism-related activities in this region, with the aim of developing a framework of sustainability indicators to assess such activities. This research seeks to support the sustainable development of tourism in the region. Therefore, I would like to invite you to participate in this interview.

Before proceeding, I will provide information regarding the ethical conduct of this research and present you with an informed consent form *[at this point, the interviewer should provide the consent form to the participant]*. If you agree to participate, you will be asked to take part in an interview lasting approximately one hour. Your responses will remain strictly confidential. All data will be collected and stored in a manner that ensures your anonymity. Participation in this study is entirely voluntary. You may withdraw at any time without providing justification, and there will be no negative consequences or penalties.

This study has been approved by the Ethics Committee of UFOB, in accordance with established guidelines for ethical conduct in research involving human subjects. You are encouraged to contact the research team if you have any questions or wish to discuss any aspect of the study. If you have any concerns regarding the ethical aspects of this research, you may contact the Ethics Committee of UFOB using the contact information provided in the informed consent form.

Do you have any questions about the study? *[Wait for the participants response and address any questions]*. If you agree to participate, please read and sign the informed consent form. Thank you. We are now ready to begin the interview.

Section 1 Icebreaker and Background

Rationale: This section aims to encourage the participant to speak about themselvestopics they are familiar within order to foster comfort and rapport. It is also essential for understanding different motivations and needs (e.g., whether the activity is carried out as a primary source of income, supplementary income, personal interest, perceived regional potential, social influence, or status).

1.1 Please tell me about your background and your involvement in tourism-related activities.
[Allow the participant to respond freely. If not mentioned spontaneously, ask:]

- **a.** In which year did you begin working in tourism?
- **b.** How and why did you start working in tourism? (What motivated you?)
- **c.** Do these motivations remain the same today? Are your current reasons for engaging in this activity the same as when you started?

Section 2 Envisioning the Future

Rationale: By exploring future expectations, it is possible to understand how the participant (e.g., tour guide, restaurant owner, lodging owner, professional climber, or landowner with a tourist attraction) envisions tourism development. This will support the identification of potential sustainability indicators across different dimensions. It also explores perceptions of individual and collective participation, barriers to engagement, and relevant initiatives.

2.1 In your view, what would be the ideal future scenario for tourism in this location?
(What kind of future do you envision for tourism here?)
[Take note of which sustainability dimensions are addressed.]

2.2 In your opinion, what would be necessary today to achieve this scenario?
(What changes would be required?)

2.3 What contribution could you personally make toward achieving this scenario?

2.4 Are there other individuals, institutions, or organizations that should be involved in building this scenario? What would their roles be?

2.5 If the participant indicates that the scenario depends on opportunities:

- What do you consider to be a good opportunity?
  - **a.** Can you provide an example?
  - **b.** Why do you consider this a good opportunity?
  - **c.** What benefits would this opportunity bring?
  - **d.** What potential negative impacts might arise?

2.6 If the participant does not envision a future scenario or prefers to maintain current activities:

- **e.** Is there any reason why you do not envision a future scenario? Please elaborate.
  [Observe whether this is related to comfort, discouragement, political dissatisfaction, or family issues.]
- **f.** Are the reasons that led you to work in tourism today the same as when you initially started?
- **g.** Do you believe that the current situation will remain stable over time?
  - **If yes:**
    g.1 Why? What factors contribute to maintaining the current scenario?
  - **If no:**
    g.1 What factors are affecting the current scenario?
    g.2 Are there individuals or institutions that should be involved in maintaining or improving this scenario? What would their roles be?

Section 3 Sustainability

Rationale: This section encourages participants to reflect on their understanding of sustainability, whether tourism activities are currently sustainable, perceived positive and negative aspects, and opportunities for improvement. These insights will support the identification of indicators aligned with local perceptions.

3.1 What does sustainability mean to you?
(Do you know the term sustainability?)
[If necessary, provide examples. Record whether the participant understands the concept and how they interpret it (e.g., durability, continuity, idealized concept, etc.).]

3.2 What do you consider sustainability (or a similar concept) in tourism?

3.3 Based on your understanding, do you believe that tourism is currently occurring in a sustainable way?

If YES:

- **a.** What are the main positive aspects?
- **b.** To whom or what do you attribute these positive aspects?
- **c.** What benefits and/or negative impacts does tourism bring?
  [Note whether effects are perceived individually or collectively.]
- **d.** Is there anything that could be improved to enhance sustainability?

If NO or UNCERTAIN:

- **e.** What aspects need improvement?
- **f.** What should remain unchanged?

g. What are the causes of these negative aspects?

h. To whom or what do you attribute these negative aspects?

i. What benefits and/or negative impacts does tourism bring?

j. When did these aspects become noticeable to you?

k. What actions should be taken to address or mitigate these issues? Who should be involved?

3.3 Additional prompts (if sustainability dimensions were not addressed):
In relation to the _____ dimension, do you consider tourism to be sustainable?

- **If YES:**
  - **a.** What are the main positive aspects?
  - **b.** To whom or what do you attribute them?
  - **c.** What benefits does tourism bring?
  - **d.** What could be improved?
- **If NO or UNCERTAIN:**
  - **e.** What needs improvement?
  - **f.** What are the causes of these issues?
  - **g.** To whom or what do you attribute them?
  - **h.** What negative impacts does tourism bring?
  - **i.** When did these issues begin to concern you?
  - **j.** What actions should be taken and who should be involved?

3.4 Do you believe you have responsibility in promoting sustainable tourism? In which aspects?

3.5 To whom else do you attribute this responsibility?

Add File 4. Indicators selected based on the contextualization of local perspectives and classified by dimension.

Table 6.

Dimension	Indicators	Measurement	Source
Environmental	Intensity of use (disturbance of fragile species and ecosystems)	Control of visitor use intensity (population health of key indicator species)	UNWTO, 2004
	Perception of use levels and overcrowding	Percentage of tourists (exit survey) and residents (local survey) who believe the destination is overcrowded.	UNWTO, 2004
	Effects of water pollution on the destination's image	Perception of food and water quality (exit survey)	UNWTO, 2004
	External threats to the environmental dimension	Adapted from: Perception of environmental risks and landscape conditions (local survey)	UNWTO, 2004
Economic	Seasonality measurement	Tourist arrivals by month or quarter (distribution throughout the year and annual trends); ratio between the number of tourists during the peak month and the period of lowest visitation; monthly accommodation occupancy rates; percentage of total accommodation occupancy during the peak quarter (or month); monthly inquiries at tourist information centers (ratio between peak and low visitation periods).	UNWTO, 2004
	Strengthening tourism during shoulder and low seasons	Percentage of the tourism authority's budget invested during the shoulder and low seasons; number of facilities offering alternative activities during the shoulder and low seasons to reduce seasonality; percentage of major attractions remaining open during the shoulder and low seasons; special events held (e.g., festivals and conferences), including the number of events and participants.	UNWTO, 2004
	Seasonal employment and issues related to lack of stable income	Number and percentage of tourism-sector jobs that are permanent (year-round); percentage of tourism-sector jobs lasting less than six months; local unemployment rate during the low season.	UNWTO, 2004
	Total annual income generated by the community	Relationship between income derived from tourism and traditional income-generating activities; relationship between the time devoted to tourism and traditional income-generating activities; relationship between the time devoted to tourism and tourism revenues (i.e., income per hour worked).	UNWTO, 2004

Continued...

Table 6.

Dimension	Indicators	Measurement	Source
Governance	Availability of information	Number and types of media and communication channels used to promote sustainable tourism (e.g., audiovisual media, printed materials, events, and the Internet); number of locations within the destination where tourism information is available.	UNWTO, 2004
	Public participation	Degree of participation of different stakeholder groups in the planning process (e.g., number of meetings, communication channels, and other consultation mechanisms used, as well as the level of participation); degree of stakeholder participation in the implementation of tourism plans (e.g., number and percentage of participants involved in evaluations, advisory groups, and other participatory mechanisms).	UNWTO, 2004
	Destination image among tourists	Percentage of tourists with a positive image of the destination; percentage of tourists who would recommend the destination to others; responses to key questions regarding the destination's main attractions and activities (exit survey).	UNWTO, 2004
	Understanding of sustainable tourism planning	Percentage of people who clearly understand the role of sustainable tourism planning (e.g., understanding the concept of sustainable tourism).	UNWTO, 2004
Social	Lifestyle changes	Number of social services available to the community as a result of tourism (percentage attributable to tourism); percentage of people who believe that tourism has contributed to the creation of services or infrastructure; number (or percentage) of people participating in handicrafts, community activities, and traditional customs; percentage of native architecture preserved.	UNWTO, 2004
	Threats to the integrity and authenticity of heritage assets	Percentage of residents who have changed their traditional occupation; variation in the number of residents participating in traditional events; increase or decrease in cultural activities or traditional events (e.g., percentage of the native population attending such events).	UNWTO, 2004
	Social benefits attributed to tourism	Increase or decrease in threats, and the types of threats that place the authenticity and original function of the property at risk (risk perception).	UNWTO, 2004
	Maintenance of a diversity of products offered	Number of different attractions within or near the destination (classified by attraction type, such as cultural and natural heritage sites, events and festivals, recreational activities, and recreation sites, among others).	UNWTO, 2004

* UNWTO= United Nations World Tourism Organization.