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Sustainability of artisanal fisheries in Guarapari, Espírito Santo, southeastern Brazil: An evaluation based on the MESMIS

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ABSTRACT

This study analyzes the sustainability of artisanal fisheries based on social, economic, and ecological indicators and on the traditional knowledge of artisanal fishermen from Guarapari, Espírito Santo, southeastern Brazil. The data were obtained through individual ethnographic interviews (n = 102) and participant and direct observation. Regarding the sustainability of fishing activities, the following indicators were selected: participation and social organization, ecological perception, satisfaction, innovation, ecological characterization of artisanal fishing, profitability, and traditional and governmental measures. These were analyzed by the MESMIS methodology and descriptive statistics. All the interviewees were male, aged between 28 and 70 years old, had a low education level and had been fishing for between 14 and 60 years. Most indicators showed a low sustainability scale. From the perspective of artisanal fishermen, fishing is not being carried out in a sustainable way due to overfishing, marine pollution, the use of predatory artifacts, noncompliance with the closed season, a lack of public policy and insufficient dialogue among stakeholders. The results of this study also enable suggesting collective and applicable actions by public managers and traditional fishing communities in regard to fishery sustainability assessments.

Keywords: artisanal fisherman; state of Espírito Santo; sustainability assessment; traditional knowledge.

Sustentabilidade da pesca artesanal em Guarapari, Espírito Santo, sudeste do Brasil: Uma avaliação baseada no MESMIS

RESUMO

Este estudo teve como objetivo analisar a sustentabilidade da pesca artesanal com base em indicadores sociais, econômicos e ecológicos, bem como no conhecimento tradicional de pescadores artesanais de Guarapari, Espírito Santo, sudeste do Brasil. Os dados foram obtidos por meio de entrevistas etnográficas individuais (n = 102) e observação participante e direta. Quanto à sustentabilidade das atividades pesqueiras, foram selecionados os seguintes indicadores: participação e organização social, percepção ecológica, satisfação, inovação, caracterização ecológica da pesca artesanal, rentabilidade e medidas tradicionais e governamentais. Tais indicadores foram analisados mediante a metodologia MESMIS e estatística descritiva. Todos os entrevistados eram do sexo masculino, com idades entre 28 e 70 anos, têm baixo nível de escolaridade e tempo de atividade pesqueira variando de 14 a 60 anos. A maioria dos indicadores apresentou baixo nível de sustentabilidade. Na perspectiva dos pescadores artesanais, a pesca não é realizada de forma sustentável por causa da sobrepesca, da poluição marinha, do uso de petrechos predatórios, do descumprimento do período de defeso, da falta de políticas públicas e do diálogo insuficiente entre as partes interessadas. Os resultados deste estudo permitem sugerir ações coletivas e aplicáveis por gestores públicos e comunidades pesqueiras tradicionais no que diz respeito às avaliações de sustentabilidade da pesca.

Palavras-chave: pescadores artesanais; estado do Espírito Santo; avaliação da sustentabilidade; conhecimento tradicional.

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INTRODUCTION

Sustainability is a term synonymous with sustainable development, whose classical concept is a development that meets the needs of the present without compromising the needs of future generations (Côrtes et al., 2019; Hajaian & Kashani, 2021). The discussion about sustainability based on the rational use of natural resources is still incipient, as it is based mainly on interest in economic growth (Barkemeyer et al., 2014). This discussion is more intense in terms of actions involving marine and coastal ecosystems, especially following the definition of the Sustainable Development Goals in the 2030 Agenda and the Decade of Ocean Science (Zappes et al., 2021). The sustainability of artisanal fisheries is included in this issue; their impacts have been presented at world environmental conferences for more than a decade (Crain et al., 2009).

Artisanal fishing is a traditional activity performed by fishermen who work alone or in partnership with family members and/or community members where simple instruments are used in vessels with low autonomy and, consequently, the fishing areas are close to the coast (Abreu et al., 2020; Lima et al., 2019). This activity is declining worldwide, mainly due to the global decrease in fishing stocks, deterritorialization of fishing communities, marine pollution and lack of fishing management (Amaral & Jablonski, 2005; Edgar et al., 2018). Associated with this, there are the ongoing deficiencies in inspections and compliance with public policies aimed at maintaining the practice of fishing (Musiello-Fernandes et al., 2017).

In Brazil, artisanal fishing is practiced along the entire coast by traditional communities whose culture and economy derive from this activity (*e.g.*, Abreu et al., 2020; Da Cal Seixas et al., 2012; Di Beneditto et al., 1998). These communities have vast traditional knowledge, defined by Brazilian legislation as the "information or practice of an indigenous population, traditional community or traditional farmer concerning the properties or direct or indirect uses associated with its genetic heritage" (Brasil, 2015a). This knowledge is elaborated via the experiences of local actors in the environment and has increased over generations, fostering conservation strategies for economically exploited regional resources (Mauro & Hardison, 2000).

Given the complexity of artisanal fisheries as socioecological systems, comprehensive approaches are required to evaluate their sustainability. In this context, the MESMIS framework (*Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales Incorporando Indicadores de Sustentabilidad*) has emerged as an important tool for assessing ecological, social, and economic dimensions in an integrated and cyclical manner (Côrtes et al., 2019; López-Ridaura et al., 2002; Masera et al., 1999). Developed in 1995 by an interdisciplinary research group in Mexico, MESMIS was originally designed to address the need for management tools capable of assessing agricultural production systems and supporting the transition toward more sustainable practices in rural communities (López-Ridaura et al., 2002; Masera et al., 1999). Since then, the framework has been applied in a variety of environmental and productive systems, supporting the development of management and restoration strategies for exploited natural resources.

Despite the growing importance of sustainability assessments in fisheries, studies applying the MESMIS framework to artisanal fishing systems remain limited. In the context of fisheries systems, studies that have applied the MESMIS framework include those conducted by Côrtes et al. (2019), Cotrim (2015), and Silva et al. (2013). Côrtes et al. (2019) investigated the sustainability of mangrove crab (*Ucides cordatus*) harvesting in areas outside protected areas, identifying the strengths and weaknesses of the production system in the state of Rio de Janeiro. Cotrim (2015) applied the methodology to evaluate the sustainability of small-scale fisheries production systems in the municipality of Tramandaí, Rio Grande do Sul. Silva et al. (2013) assessed the sustainability of extractive activities carried out by a fishing community located within the Ibura National Forest, a protected area situated in the state of Sergipe, Brazil.

Studies that evaluate the economic, ecological, and social relationship of traditional fishing communities are necessary for the development of management actions that ensure the sustainable use of fishing resources. Based on this, the objective of this study was to determine the sustainability of artisanal fisheries based on social, economic, and ecological indicators developed with the MESMIS methodology, incorporating sustainability indicators, and based on the traditional knowledge of artisanal fishermen from Guarapari, Espírito Santo, southeastern Brazil.

METHOD

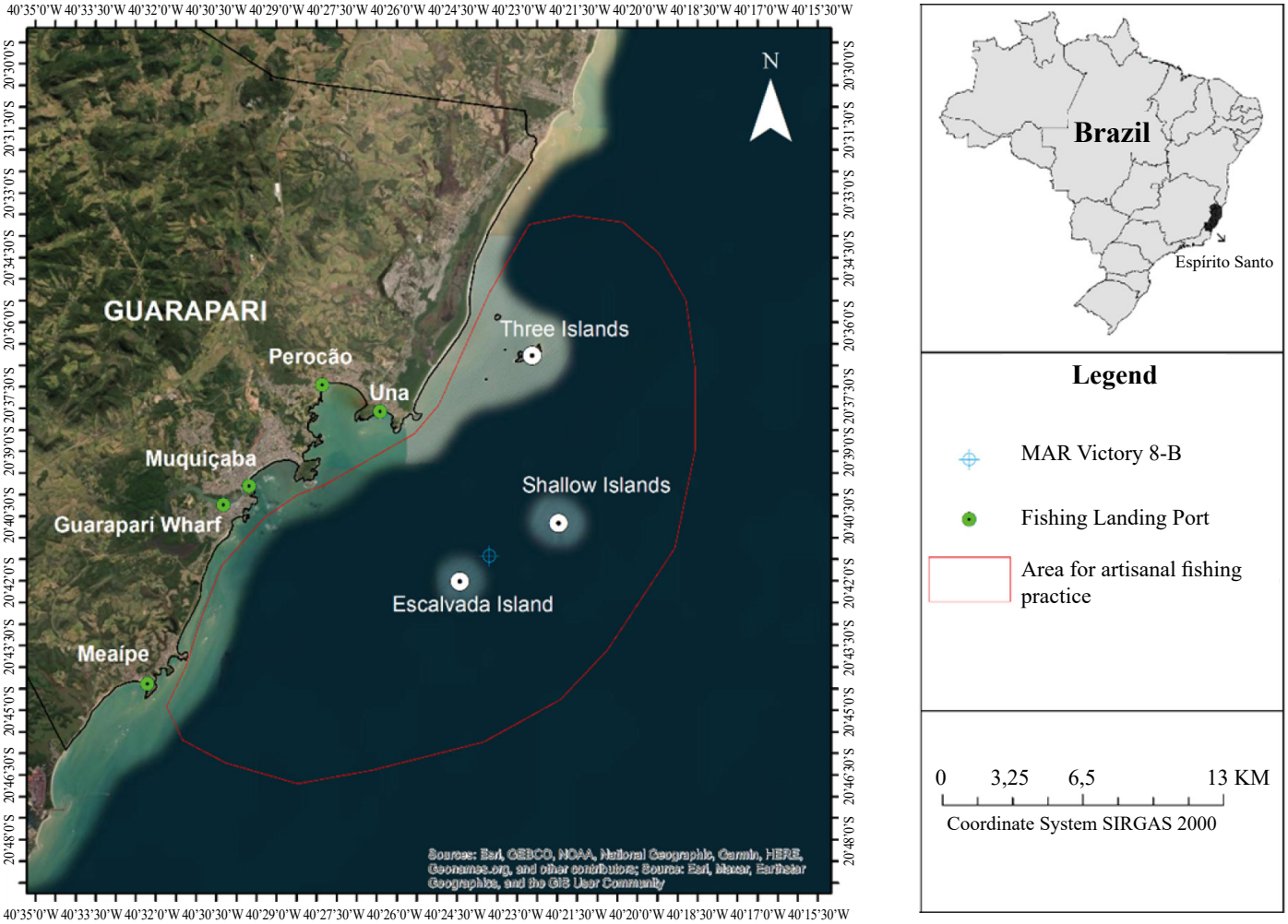
Study area

The municipality of Guarapari (20°38'S–40°27'W), located in the coastal mesoregion of the state of Espírito Santo, southeastern Brazil, has approximately 129,000 inhabitants (IBGE, 2022). The local fishing activity is predominantly artisanal, involving approximately 1,400 fishermen, 350 vessels registered in the General Fisheries Activity Registry and five fish landing ports (Abreu et al., 2020). Such characteristics indicate the importance of the activity for the local economy (Abreu et al., 2020; 2022). The coast of the municipality is composed of

coastal islands and the Victory 8-B artificial reef, habitats for the species targeted by artisanal fisheries, area where artisanal fishing is practiced (Fig. 1) (Abreu et al., 2022).

Procedures

Between January and May 2022, 102 individual ethnographic interviews were conducted (Schensul et al., 1999) through



Source: Authors, 2025.

Figure 1. Location of the municipality of Guarapari, Espírito Santo, southeastern Brazil, with indications of the coastal islands, artificial marine reef Victory 8-B, area for artisanal fishing practice, and fishing ports of landing.

dialogue with artisanal fishermen registered in Fishermen's Colony Z-3 located in Guarapari. The interviews were based on a semistructured questionnaire with open (n = 5) and closed (n = 30) questions, which was adaptable and allowed the addition of relevant information (Schensul et al., 1999). Due to the formation of a pattern of responses among respondents, the saturation point, *i.e.*, the number of conducted interviews (n = 102), is considered adequate for the present study (Mason, 2010).

The interviewees were approached according to the following criteria:

- Being artisanal fishermen;
- Being registered in the Z-3 Fishermen's Colony;
- Practicing artisanal fishing in the study area.

The exclusive participation of men among the interviewees reflects the local reality, where women are primarily involved in fish processing activities rather than fishing operations and fish capture. The selection of the first interviewee was performed with the help of a local guide, and the snowball method was used for the following interview (the interviewee indicates potential respondents) (Bailey, 1982; Howard et al., 2001). In cases of the

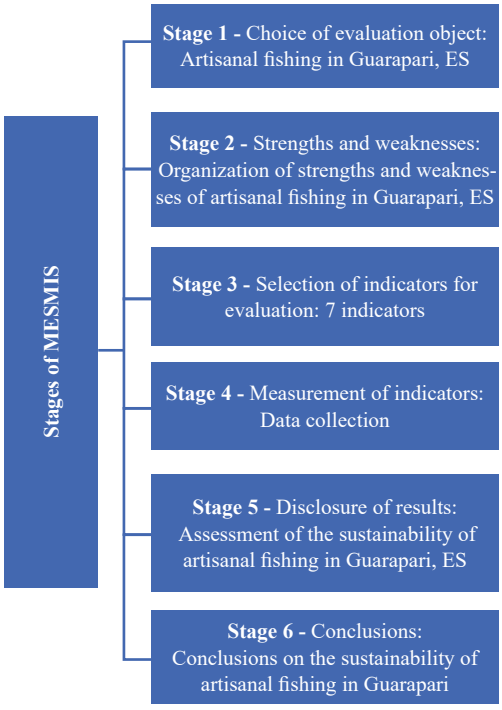
interruption of this method, the interviewees could be selected through opportunistic meetings.

Participatory and direct observations were performed to learn about the fishing routines and to generate a bond of trust among those involved (Lopez-Dicastillo & Belintxon, 2014). At the end of each day, observations regarding the object of study were recorded in a field journal (Wolfinger, 2002).

The research project to which this study is linked is the National System for the Management of Genetic Heritage and Associated Traditional Knowledge, number AF42FD7, approved by the Plataforma Brasil/Ethics Committee (CAAE: 03219018.0.0000.5243) in compliance with Brazilian legislation (Brasil, 2015a).

Data analysis

Data analysis included triangulation, in which the information was collected through participant and direct observation, and field diaries and interviews were combined, enabling data comparison (Blaikie, 1991; Yeasmin & Rahman, 2012); basic descriptive statistics (Kaur et al., 2018); and the MESMIS framework (Côrtes et al., 2019; López-Ridaura et al., 2002; Masera et al., 1999), composed of six steps (Fig. 2).



Source: Adapted from Côrtes et al. (2019).

Figure 2. Stages of the MESMIS framework methodology applied to artisanal fisheries in the municipality of Guarapari, Espírito Santo, southeastern Brazil.

The questions of the questionnaire related to the MESMIS framework were divided into social, ecological, and economic dimensions. Each question had five response alternatives on equal scales: 0, 25, 50, 75, and 100%, where 0% meant the worst-case scenario and 100% the best-case scenario (Côrtes et al., 2019; Sarandón et al., 2006). The variables for the social, ecological, and economic dimensions were adapted from Côrtes et al. (2019), Navarro and Álvarez (2015) and Sarandón et al. (2006), due to their similarity with this study and classified into productivity attributes: stability, resilience, reliability, adaptability, equity, and self-management (Navarro & Álvarez, 2015).

For each sustainability indicator, the following values were defined: the minimum value (Min) represented the undesirable level of sustainability, while the maximum value (Max) represented the desirable level of sustainability. The analysis included the observed value, the normalized variable value, which indicates the sustainability level of each variable, the normalized indicator value, representing the sustainability level of each indicator, the normalized dimension value, corresponding to the sustainability level of each dimension, the dimension sustainability scale, and the overall sustainability index of the artisanal fishery in Guarapari (Table 1) (Côrtes et al., 2019). In this study, a four-level scale was adopted to facilitate the interpretation and communication of the results:

- 0–25% = very low sustainability (critical situation);
- 26–50% = low sustainability (significant vulnerabilities);
- 51–75% = moderate sustainability (moderate performance; improvements required);
- 76–100% = high sustainability (good sustainability performance).

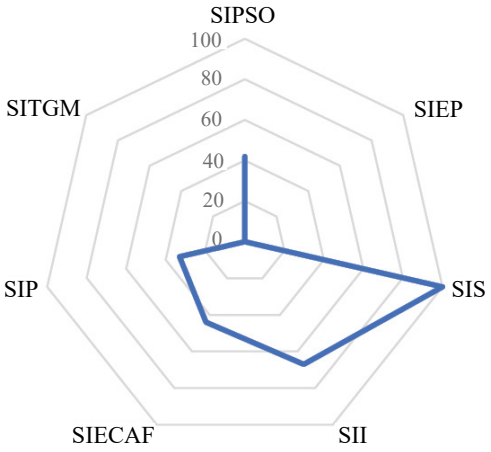
RESULTS

The evaluation of the sustainability of artisanal fishing based on the perceptions of the fishermen interviewed is shown in Table 1 and Fig. 3. The overall sustainability index (38%) indicates a low level of sustainability.

Sustainability indicators participation and social organization (SIPSO) was 42%, indicating significant vulnerabilities. The employment relationship (94.11%; n = 96) in the fishing system is predominantly artisanal, performed by men with low education (97%; n = 99). The percentage of active fishermen is described by 60% (n = 62) of respondents as falling, 30% (n = 29) increasing, and 10% (n = 11) stable. Most of the interviewees (93%; n = 95) benefit from the closed fishing insurance, a national public policy providing a financial benefit to fishermen during the interruption of fishing activity aimed at the conservation of a target species.

Table 1. Dimension, sustainability indicator, variables, minimum (Min), maximum (Max), observed value (OV), normalized variable value (NVV), (sustainability level of each variable), normalized indicator value (NIV), (sustainability level of the indicator), normalized dimension value (NDV), (sustainability level of the dimension), dimension sustainability scale (DSS), and the overall sustainability index of artisanal fisheries in Guarapari, Espírito Santo, southeastern Brazil.

Dimensions	Sustainability indicators	Variables	Min (%)	Max (%)	OV (%)	NVV (%)	NIV (%)	NDV (%)	DSS
Social	Participation and social organization	Employment relationship	25	100	75	67	42	52	Moderate sustainability
		Formal education	25	75	50	50			
		Active fishermen	25	75	50	50			
		Conditions and health care	25	50	25	0			
	Ecological perception	Impacts of fishing activity on fisheries	0	100	100	0	0		
		Anthropogenic impacts on fisheries	0	100	100	0			
		Vulnerability of the marine ecosystem	0	100	100	0			
	Satisfaction	Interest in remaining in the activity	0	100	100	100	100		
	Innovation	Ability to use new technologies	25	100	75	67	67		
Ecological	Ecological characterization of artisanal fisheries	Captured species	25	75	50	50	44	44	Low sustainability
		Discard level	25	100	75	33			
		Selectivity of the fishing gear	25	75	50	50			
Economic	Profitability	Fisherman's average income	50	100	50	0	33.5	17	Low sustainability
		Income derived from fishing	25	100	75	67			
	Traditional and governmental measures	Incentives from the government for fishing	25	50	25	0	0		
		Traditional measures that regulate fishing	25	50	25	0			
		Government measures regulating fishing	25	50	25	0			
Overall sustainability index								38	Low sustainability



SIPSO: sustainability indicators participation and social organization; SIEP: sustainability indicators ecological perception; SIS: sustainability indicators satisfaction; SII: sustainability indicators innovation; SIECAF: sustainability indicators ecological characterization of artisanal fisheries; SIP: sustainability indicators profitability; SITGM: sustainability indicators traditional and governmental measures. Source: Authors (2025).

Figure 3. Sustainability level of the social, ecological, and economic dimensions of artisanal fisheries in Guarapari, coastal mesoregion of the state of Espírito Santo, southeastern Brazil, from the perspective of local fishers.

During the closed season, which lasts an average of three months a year, each fisherman receives USD $ 232.58 (R$ 1,200.00 values in Brazilian reals between 2020 and 2022) (Brasil, 2015b). Regarding health care, 73% (n = 75) of the respondents reported that it is bad, and 27% (n = 27) good.

Sustainability indicators ecological perception (SIEP) relates to the impacts caused by fishing activity, anthropic impacts on fisheries, and vulnerability of the marine ecosystem, and the normalized indicator value was 0%. All respondents (100%; n = 102) recognized the impacts, but they are unaware of the ways to mitigate negative interference and/or conserve the marine ecosystem. According to 45% (n = 45) of the interviewees, the impact of fishing activity on fishing is high, followed by do not know how to inform (35%; n = 34), medium (18%; n = 18) and low (2%; n = 5). Regarding the influence of anthropic impacts on artisanal fisheries, 68% (n = 69) described it as increasing, while the others reported that it does not exist (14.4%; n = 15), it is stable (12.6%; n = 13) or falling (5%; n = 5). The vulnerability of the marine ecosystem was indicated by 44% (n = 45) of respondents as high. However, 30.5% (n = 31) are unaware of it or classified it as stable (22.5%; n = 23) or low (3%; n = 3).

Respondents showed interest in remaining in their fishing activity, which indicates a good sustainability performance of the sustainability indicators satisfaction (SIS). In Guarapari, 76% (n = 77) of the interviewees stated that they do not practice any other paid activity. The remainder engage in other remunerated activities concomitant with fishing, such as tourism (16%; n = 17) or civil construction (8%; n = 8). Regarding the sustainability indicators innovation (SII) (67%), 99% (n = 101) make use of technologies such as radio communication (41,8%; n = 87), global position system (39.4; n = 82) and sonar (16.8%; n = 35) (Table 2). All fishermen use more than one type of technology, which explains the higher number of responses (n = 208) than respondents (n = 102).

Table 2. Fishing technologies used by artisanal fishers in Guarapari, coastal mesoregion of the state of Espírito Santo, southeastern Brazil.

Technology	Reports	Percentage (%)
Radio communication	87	41.8
Global positioning system	82	39.4
Sonar	35	16.8
Compass	4	1.9
Total	208	100

The sustainability indicators ecological characterization of artisanal fisheries (SIECAF) shows a normalized indicator value of 44%, indicating low sustainability. According to 56.9% (n = 58) of the interviewees, up to 10 ethnospecies of bony fish are captured, and for 31.4% (n = 32) up to five ethnospecies (Table 3). These ethnospecies are destined for the local market (80%; n = 54). Forty-five percent (n = 46) of the interviewees reported that their fishing areas have not changed, while 55% (n = 56) cited some type of change, such as an increase or decrease in fishing area. Regarding the amount of fishery discarded, 88% (n = 90)

Table 3. Number of bony fish ethnospecies captured by artisanal fishers in Guarapari, coastal mesoregion of the state of Espírito Santo, southeastern Brazil.

Number of ethnospecies captured	Reports	Percentage (%)
Up to 10	58	56.9
Up to five	32	31.4
More than 10	11	10.8
One	1	1.0
Total	102	100

considered it low; 8% (n = 8) average; and 4% (n = 4) high. Regarding the selectivity of fishing gear, 85% (n = 87) of respondents stated that they have high selectivity.

According to 57% (n = 58) of respondents, their monthly income is more than USD $ 426.59 (R$ 2,201.00 in Brazilian real between 2020 and 2022), while 35% (n = 35) receive between $ 232.58 and $ 426.40 (R$ 1,200.00 and R$ 2,200.00 in Brazilian reals between 2020 and 2022); 8% (n = 9) receive less than $ 232.58 (R$ 1,200.00 in Brazilian reals between 2020 and 2022). This income is derived only from fishing activities (84%; n = 86).The sustainability indicators profitability (SIP) value of 33.5% indicates significant vulnerabilities to sustainability.

The normalized value of sustainability indicators traditional and governmental measures (SITGM) is low. The public power incentive is unknown by 71.5% (n = 73) of the interviewees; 23.5% (n = 24) considered this incentive low, and 5% (n = 5) reasonable. Regarding the traditional measures that regulate fishing, 71.5% (n = 73) of the interviewees were unfamiliar with them, 26.5% (n = 27) considered them less than acceptable, and 2% (n = 2) reported them to be reasonable. The government measures that regulate fishing are not known by 73.5% (n = 75) of respondents and are classified as inferior and reasonable by 25.5 (n = 26) and 1% (n = 1), respectively.

DISCUSSION

Social dimension

In the studied region, the work relationship is artisanal, performed by middle-aged adults who are the main actors in artisanal fisheries (Abreu et al., 2020). The variable presents a real value of average sustainability, which demonstrates that traditional knowledge is passed down between generations, with the most experienced sharing their teachings with beginners (Abreu et al., 2020; 2022). However, the drop in production and the lack of investment in the sector discourages young people from remaining in the activity and, consequently, reduces the number of fishermen to the detriment of local culture (Alves et al., 2018; Mauro & Hardison, 2000; Milanez, 2015). This scenario reflects the limited effectiveness of public policies aimed at strengthening artisanal fisheries, particularly regarding youth retention, generational succession, and socioeconomic support for traditional fishing communities.

The low level of education among the participants is explained by their early entry into fishing activities with the aim of supplementing family income, which reflects the low level of sustainability of the activity in relation to formal education (Oliveira et al., 2016; Oliveira et al., 2020). This characteristic is common in fishing communities along the coastal mesoregion of the state of Espírito Santo, southeastern Brazil (Abreu et al., 2022; Braga et al., 2018; Carvalho et al., 2016; Musiello-Fernandes et al., 2020). The lack of opportunity for formal and professional education renders fishermen workers with little knowledge of how to improve their living conditions, work in other economic sectors or avoid work accidents (Alencar & Maia, 2011).

Unfortunately, accidents and the development of diseases are common situations in artisanal fishing related to the poor working conditions of fishermen (Alves et al., 2018; Dahlgren & Whitehead, 1991). In Brazil, any citizen is entitled to free health care through the Unified Health System (Brasil, 1990). Conditions and health care have not reached ideal sustainability, and the interviewees in this study reported that these are considered poor due to the distances of their communities from large centers, which makes it difficult to access specialized treatment. Thus, preventive health care measures are necessary in these communities to avoid and prevent diseases and accidents at work, improving the quality of life of artisanal fishermen. The persistence of these deficiencies demonstrates shortcomings in public policies related to healthcare accessibility and occupational safety in traditional coastal communities.

As observed, SIPSO presents inefficiency in its social organization due to the drop in the number of active fishermen, low education level and precarious conditions and health care, following a pattern observed on the coasts in the states of Espírito Santo and Rio de Janeiro (Abreu et al., 2022; Alves et al., 2018; Braga et al., 2018; Carvalho et al., 2016; Musiello-Fernandes et al., 2020; Oliveira et al., 2016). In Latin American countries, the sustainability of a system depends mainly on the participation of stakeholders to incorporate traditional knowledge in the creation and application of measures for sustainability (Speelman et al., 2007). This situation indicates the need to create public policies for reproduction and social participation in fishing communities.

Any human activity has an impact on the environment, whether positive or negative (Wiber et al., 2012). The SIEP shows that there is a need to provide environmental education to fishermen to disseminate information on impact prevention measures to ensure fishing sustainability (Reyes & García, 2022). The artisanal fishermen interviewed recognized the negative impacts caused by fishing and the vulnerability of the coastal ecosystem in their region. This recognition opens the possibility for comanagement measures aimed at joint and effective solutions to coastal environmental problems (Abreu et al., 2017; Moura & Diegues, 2024). Thus, it is possible to propose actions that contribute to a dialogue between public managers and traditional

communities, establishing avenues for discussion and ensuring environmental conservation, the credibility of local knowledge, and the maintenance of economic activity (Awabdi et al., 2018; Mauro & Hardison, 2000).

On the other hand, the SIS shows a positive tendency of fishermen to remain in the activity, which justifies the good performance for sustainability. Reductions in fish stocks motivate artisanal fishermen to seek alternative economic activities to improve their quality of life (Fitton et al., 2016). In the studied region, tourism is the main alternative activity performed by the fishermen interviewed. Knowledge of the regional marine ecosystem allows these fishermen to act as informal tour guides and offer visitors more affordable prices for boat trips than regular tourism agencies (Abreu et al., 2021).

In Guarapari city, geography favors the diversity of environments and target species near the coastline; even so, fishermen in the region need to work in areas increasingly distant from the coast and with new technologies so that their activity maintains profitability (Abreu et al., 2022). The technologies used by fishermen for capture and location at sea are efficient, which contributes to the SII performance related to fishing sustainability. These innovations increase catches and benefit the physical health of artisanal fishermen, but their lack of technical assistance can cause an overexploitation of resources and, consequently, the unsustainability of fish stocks (Côrtes et al., 2019).

Ecological dimension

The variation in species composition and environments in the studied region has been described by Abreu et al. (2020; 2021) and is due to the presence of an insular complex formed by rocky islands and marine artificial reef (RAM), which provide feeding, spawning and protection and the passage of target species near the coast. Studies conducted in Mexico indicate that RAMs contribute to the recovery and conservation of fish stocks in a sustainable manner (Reyes & García, 2022). However, in Guarapari, the presence of a RAM is not enough to maintain the local fish stock because predatory fishing and inappropriate uses of artifacts compromise the proliferation of marine life, thereby causing disputes over space and resources (Abreu et al., 2022).

Line, gillnet, harpoon and longline are the main artifacts used, recognized by the fishermen interviewed as selective and with a low level of discard, albeit with low values for sustainability. Identification is part of their knowledge acquired due to a set of experiences during fishing, but the increase in fishing efforts, irregular use of artifacts, and lack of research compromise such activity (Abreu et al., 2022; Morin-Labatut & Akhtar, 1992). The absence of continuous public investment in research, technical assistance, and environmental education limits the development of adaptive management strategies capable of ensuring resource sustainability. To achieve the desired scale of sustainability for SIECAF, it is necessary to use traditional knowledge in the development of actions aimed at the management of natural resources to contribute to the creation of educational practices and the conservation of fish stocks (Côrtes et al., 2019; Sillitoe, 1998; Wilson et al., 2006).

The fishermen interviewed reported that the commercialization of fish occurs in the region itself and that the values vary according to availability. This scenario shows that the community depends on middlemen as one of the links in the production chain, *i.e.*, marketing agents (Abdallah & Sumaila, 2007). Côrtes et al. (2019) mention that this dependence on middlemen and the absence of cooperatives to commercialize fish reduce fishermen's profits. Thus, it is necessary to create adequate places for the commercialization of fish, which could expand the market while reducing fishing efforts and the dependence on middlemen.

Economic dimension

The SIP corresponds to the average income of artisanal fishermen, approximately USD $ 400.00, slightly more than the Brazilian minimum wage (R$ 2,200.00) in the municipality. The VNI found shows low vulnerability, since in the fisherman's perception the value received is low due to expenses with maintenance of fishing gear and vessels, in addition to maintaining family expenses (Oliveira et al., 2016). Closed season insurance is an income alternative for artisanal fishermen paid by the federal government amid the temporary suspension of their activity (Brasil, 2015b; Musiello-Fernandes et al., 2017). However, the value of this benefit is at least twice as low as the monthly income normally generated by fishing. Braga et al. (2018) thus report that fishermen in the studied region often act illegally during the closed season to supplement their income, increasing their efforts in fishing stocks.

The low values observed for the SITGM demonstrate the inadequacy of existing public policies and highlight the urgent need for governmental measures capable of addressing the economic vulnerabilities of artisanal fishermen. The absence of dialogue between traditional communities and the government makes it difficult to implement measures and generates a possible scenario of conflict (Mauro & Hardison, 2000). The participation of fishermen in the creation and implementation of these measures should be considered, as it contributes to their knowledge and conservation practices (Mauro & Hardison, 2000; Wilson et al., 2006). Dialogue among stakeholders enables the creation of trust and an exchange of information

for the construction of measures that are only effective if everyone understands the need to conserve natural resources for sustainability, leading to better capture and economic return (Mauro & Hardison, 2000).

The evaluation of fishery sustainability is mainly focused on biological, economic, and social aspects (Basílio et al., 2015; Chuenpagdee & Alder, 2001). Detriment to one dimension makes it difficult to maintain the sustainability of the activity, as well as the information on the socioeconomic profiles of traditional communities (Côrtes et al., 2019). In this sense, such evaluation must involve a multidimensional aspect because systems with a desirable profile depend on the adoption of measures with alternatives in their three dimensions (biological, social, and economic) to ensure efficient management in the long term (Chuenpagdee & Alder, 2001).

In addition, traditional knowledge must be incorporated into management initiatives, in the planning process and in decision-making to devise strategies for the conservation of fish stocks (Basílio et al., 2015; Mauro & Hardison, 2000). In this regard, traditional communities, public managers and educational and research institutions need to act together to create proposals for public policies aimed at sustainable practices, as well as inspection strategies in the responsible sector to ensure the sustainability of artisanal fishing. In Table 4, proposed management measures, to be carried out jointly by traditional communities and stakeholders, are listed to promote the sustainability of artisanal fisheries in Guarapari.

Table 4. Proposals for management measures to be carried out jointly by traditional communities and stakeholders to promote the sustainability of artisanal fisheries in Guarapari, Espírito Santo, southeastern Brazil*.

Action	Reason	Stakeholders	Application	Period	Funding agency
To establish a bond of trust among stakeholders	Creation of dialogue among those involved to avoid conflicts and assist in the joint decision-making	Community leaders; teaching and research institutions; public managers; nongovernmental organizations	Include the participation of members of traditional communities in projects and decision-making	Whenever there are projects and decision-making involving fishing communities	Environmental compensation companies
To promote the appreciation of the local fishing culture of the communities involved	Understanding local culture and environmental conservation practices to ensure the credibility of traditional knowledge	Community leaders; teaching and research institution; public managers; nongovernmental organizations	Hold conversation circles in schools and public places of fishing communities so that more experienced individuals share their experiences with the beginners	Monthly	Environmental compensation companies; Public bodies related to culture
To conduct market and feasibility studies of extra income activities during the closed season	Supplementation of the family income of artisanal fishermen to prevent them from acting illegally during the closed season	Fishing communities; teaching and research institutions; public managers; nongovernmental organizations	Identify possible income-earning activities related to the local culture that are attractive to the community; conduct a commercialization and target audience study; conduct training courses on local business administration and domestic administration based on regional language with local actors	Annual	Environmental compensation companies

Continue...

Continuation.

Action	Reason	Stakeholders	Application	Period	Funding agency
To offer health care to artisanal fishing workers	Prevention of diseases and accidents at work caused by fishing	Public managers (public health service); nongovernmental organizations	Hold meetings in the communities between health and fishery workers on preventive measures and basic care	Weekly	Public authorities; Environmental compensation companies
To disseminate information on environmental conservation focused on fish stocks	Mobilization of communities on the importance of conserving fish stocks	Teaching and research institution; public managers; nongovernmental organizations	Produce informative material with regional images and language, combining traditional and scientific knowledge	Semiannual	Environmental compensation companies
To monitor fishing activity	Update of fishing data to assist in the management of the activity	Traditional communities; teaching and research institutions; public managers	Create a database with information on activities ranging from characteristics to conflicts based on information provided by artisanal fishing workers themselves	Annual	Environmental compensation companies; Environmental management bodies
To teach the MESMIS method to traditional communities	MESMIS makes it possible to assess the sustainability of fishing on a regular basis by stakeholders	Teaching and research institutions; nongovernmental organizations	Identify community members interested in learning the methodology; hold meetings in the communities to teach the MESMIS method based on booklets using regional language	Weekly	Environmental compensation companies

*These proposals have the potential to be applied in other artisanal fishing communities.

FINAL CONSIDERATIONS

The MESMIS framework is a methodology for analyzing sustainability at a local level based on analysis of social, ecological, and economic indicators, providing an interdisciplinary view of the focal system. In the view of artisanal fishermen in Guarapari, fishing is not sustainable. Most indicators showed critical points and flaws in their structure, which depend on the adoption of public policies for efficient management of the fishing system. The low OSI value is probably the result of the overexploitation of fishery resources, the absence of management plans for the activity, and the low remuneration/financial compensation that fishermen receive. Therefore, to ensure the sustainability of this activity, partnerships among regional stakeholders are needed to promote the conservation of fish stocks, maintenance of fishing culture, and income of families dependent on fishing.

CONFLICT OF INTEREST

Nothing to declare.

DATA AVAILABILITY STATEMENT

Data will be provided upon request.

AUTHORS' CONTRIBUTIONS

Conceptualization: Abreu, J.S., Zappes, C.A.; Data curation: Abreu, J.S., Zappes, C.A.; **Formal Analysis:** Abreu, J.S.,

Zappes, C.A.; **Investigation:** Abreu, J.S., Côrtes, L.H.O., Di Beneditto, A.P.M., Zappes, C.A.; **Methodology:** Abreu, J.S., Zappes, C.A.; **Validation:** Abreu, J.S., Côrtes, L.H.O., Di Beneditto, A.P.M., Zappes, C.A.; **Writing – original draft:** Abreu, J.S., Côrtes, L.H.O., Di Beneditto, A.P.M., Zappes, C.A.; **Writing – review & editing:** Abreu, J.S., Côrtes, L.H.O., Di Beneditto, A.P.M., Zappes, C.A.; **Funding acquisition:** Di Beneditto, A.P.M., Zappes, C.A.; **Resources:** Di Beneditto, A.P.M.; **Project administration Supervision:** Zappes, C.A.; **Final approval**: Abreu, J.S.

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DECLARATION OF USE OF ARTIFICIAL INTELLIGENCE TOOLS

Artificial intelligence tools were not used.

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