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Challenges and Solutions for Sustainability in Fisheries: Perspectives from Environmental Economics and Game Theory

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ABSTRACT

This study describes the findings from a literature review concerning the ecosystem and economic services of fishery resources, aiming to explain the challenges posed by overfishing in managing common-pool resources. Statistical data on the global fishing situation and Mexico's participation in a global context are presented, helping us understand the study's relevance from an economic aspect and opening the way for how researchers address fisheries sustainability issues. A total of 443 research articles classified by categories were analyzed for the period from 2014 to 2024, sourced from the Science Direct database, with the objective of recognizing the historical context and trends in fishery resource management. VOSviewer was used for keyword analysis and Scopus for querying the most cited authors. It was found that there is a complex network of strategies related to fishery management, but transferable capture quotas, community governance, and game theory are the most frequently used tools to achieve sustainable fishing.

1. INTRODUCTION

Fishing communities face a dilemma between the environmental value and economic contributions generated by the exploitation of coastal ecosystems. Human actions, such as the destruction of mangroves and maximum fishing effort, compromise biodiversity. The Sundarbans mangroves in Bangladesh are a resource used to generate livelihoods through wood consumption, leading to ecosystem degradation, reduced fish populations, and increased fishing effort [1].

Overfishing creates uncertainty in obtaining resources from various fisheries because there is no certainty about the availability and permanence of the species that are part of food security. In the southern Benguela region, the fishing sector struggles with suboptimal stock perspectives in hake and sardine species, overexploitation of rock lobster (its most commercially valuable species), and has faced the collapse of cod fisheries caused by sectoral conflicts and external factors such as climate change [2].

Environmental economics proposes achieving optimal economic outcomes to maximize benefits without compromising future fishing. In the exploitation of common resources, solutions focus on addressing externalities and overexploitation through jurisdictional limits, such as catch quotas defined by ecological parameters, Coasean costs, and governance elements aimed at conserving marine species [3].

Governance is key to the health of coastal ecosystems, and its scope is delineated by the social actors involved. Sustainability is not possible without the joint participation of governments, communities, and cooperatives, as they together decide whether to comply with or reject maritime regulations [4].

Game theory allows for generating different scenarios for decision-making, bringing job stability and local development. Game models allow observing the differences and profiles of players when presented with the opportunity to cooperate, not cooperate, or form a cartel. Scenarios for fisheries sustainability are formulated in terms of environmental and financial well-being, resulting from spillover effects from conserving fish stocks [5].

The complexity of managing fishery resources is further exacerbated by the transboundary nature of many fish populations, which migrate across national borders and require international cooperation for effective management. This calls for comprehensive frameworks that incorporate both local and global perspectives, addressing not only ecological sustainability but also social and economic dimensions [6].

The literature review will allow visualizing the challenges and evidencing the progress related to overfishing, with the aim of applying more accurate fishing policies. It aims to understand the interplay between different management strategies and the socio-economic contexts in which they are implemented. By examining case studies from diverse regions, we can identify best practices and common pitfalls, providing valuable insights for policymakers.

Furthermore, the role of technological advancements in fisheries management cannot be overstated. Innovations such as satellite tracking [7], deoxyribonucleic acid (DNA) analysis for stock identification [8], and automated monitoring systems have revolutionized the ability to enforce regulations and gather accurate data [9]. These technologies not only improve compliance but also enhance the precision of scientific assessments, leading to better-informed decision-making.

2. FISHING: A COMMON RESOURCE

Global capture fisheries production has remained relatively stable since the late 1980s, fluctuating between 86 and 94 million tonnes with an isolated peak of 96 million tonnes in 2018 (Figure 1).

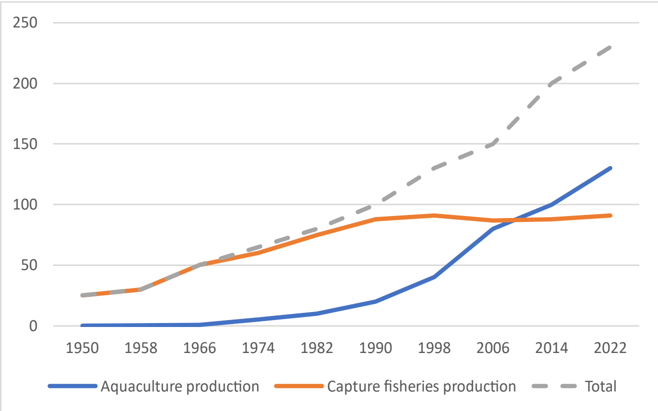

Figure 1. World fisheries production 1950-2022

In the report The State of World Fisheries and Aquaculture, the Food and Agriculture Organization (FAO) states that 230 states and territories have some commercial activity related to fishery and aquaculture products. Of the world's production of aquatic animals, including capture fisheries and aquaculture (185 million tonnes in 2022), more than 89% is used for human consumption, representing a total value of USD 452 billion in 2022, of which USD 156 billion (91 million tonnes) corresponds to capture fisheries. The largest producer of aquatic animals in areas marinas is China with 12 million tonnes, and Mexico ranks 11th among the world's producers; see Table 1 [10].

Table 1. Capture fisheries in marine areas

Country	Production 2022 (Thousand Tonnes)	Share in Total %
China	11819	14.8
Indonesia	6843	8.6
Perú	5289	6.6
Russian Federation	4717	5.9
EE. UU.	4243	5.3
India	3597	4.5
Vietnam	3443	4.3
Japan	2889	3.6
Norway	2442	3.1
Chile	2226	2.8
México	2659	2.1

Given that production and consumption patterns tend to be positive, fishing is considered a source of food security and employment. However, the absence of property rights due to the migration of fish populations and open-access geographic areas increases the extensive use of this common resource [11].

The FAO indicates that fish populations suffering from overfishing increased from 35.4% in 2019 to 37.7% in 2021, and that most fisheries are at their maximum sustainable yield level. This scenario shows differences between fishing regions in each country; Figure 2 illustrates the varying degrees of fishery resource sustainability [10].

The problems arising from the management of fishery resources are negative environmental externalities that generate social costs and affect communities [12].

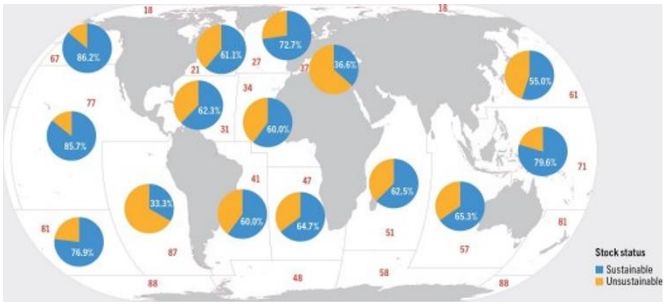

Figure 2. Percentages of fishery stocks

This highlights the need for innovative approaches that integrate economic incentives with conservation goals, ensuring that fishers have a vested interest in the long-term health of the fisheries.

In Mexico, it was recorded that by 2018 the fishing industry generated added value amounting to 35,085.7 million pesos, among all economic activities, it accounts for 0.9% of employment generation, ranking seventh, and 0.2% of added value generation, ranking ninth [13]. The fishing sector faces pressure on the most commercially valuable species and decreasing yields. The environmental performance index averages the catch based on live weight captured and the number of registered vessels. In the historical series from 1990 to 2017 (Figure 3), tuna fisheries have not recovered the values obtained in 2014, maintaining a 62% decrease. Sardine remains at 56% by 2017 compared to 1990, scale fish show significant growth of 97%, and shrimp exhibits fluctuations throughout the series, closing 2017 with a yield of 197%, a figure related to the withdrawal of vessels since 2005, which increased its competitiveness [14].

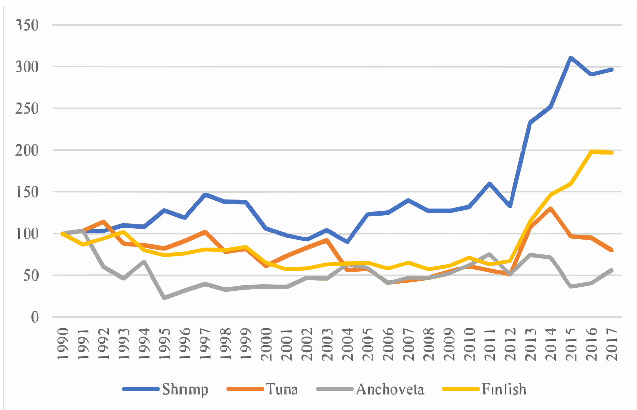

Figure 3. Capture fisheries by main species

Although successful practices are scarce in Mexico, there are some fisheries, such as lobster and tuna, whose certification strategies have managed to be sustainable thanks to state intervention and differentiated regulatory systems that achieve Pigouvian welfare [15]. Since fishing is an anchor for the subsistence of communities, proposals have been made to minimize the risk of overexploitation by rationalizing resources over time. The rule of weak sustainability is explained in terms of environmental economics [16]. Ostrom suggests that the way to address the tragedy of the commons is through collective action, strengthening voluntary agreements and institutional participation [17]. It has been demonstrated that when communities actively participate in the formulation and application of regulations, economic benefits are improved without compromising resources [18]. It is difficult to align the different expectations and opinions of the participating agents; cooperative game models explain more solidly the behavior and dynamics under which the organisms involved in fishery governance operate [19].

In addition, interdisciplinary research has increasingly shown that integrating traditional ecological knowledge (TEK) with scientific data can significantly enhance fisheries management. Local fishers often possess detailed knowledge of marine ecosystems and fish behavior, accumulated over generations. Leveraging this knowledge in combination with scientific research can lead to more effective and culturally appropriate management strategies.

3. METHODOLOGY

The literature review was conducted in the indexed database Science Direct for the period 2014-2024. The first five years provide a perspective on the persistence and evolution of the problem, while the last six years outline trends and strategies for sustainability and overfishing.

The search for scientific articles was conducted using pairs of thesauri: "sustainable fishing" and "fishing cooperatives" to identify and relate social actors to overfishing, and the terms "sustainable fishing" and "mangroves" to identify ecosystem services. Together, they explain environmental challenges. The thesauri "overfishing" and "individual transferable quotas" along with "overfishing" and "game theory" comprise two of the persistent proposals in research to solve fishery sustainability.

From the four groups, 443 articles were found, which were organized into statistical graphs to identify the publication frequency, thematic area, and type of regulatory strategy applied in different countries based on the reported case studies.

To enhance the robustness of the bibliometric analysis, the VOSviewer tool was used not only to map keywords but also to analyze co-authorship networks, citation patterns, and institutional collaborations. This provided a comprehensive view of the research landscape, highlighting key contributors and the interconnectedness of different research themes.

Using the VOSviewer tool, bibliographic references were channeled to visually identify keywords and author co-occurrence.

Moreover, an exploratory data analysis was conducted to identify emerging trends and shifts in research focus over the studied period. This included examining the evolution of research topics, the geographical distribution of studies, and the methodological approaches adopted by different authors.

For the preparation of citation tables by author, the 15 most cited articles were identified in Science Direct, and then the Scopus database was used to access author profiles. With the collected information, a productivity table is presented.

The articles were also filtered and reduced to conduct a careful analysis of 79 open-access articles and 113 with access to summaries. In the results, we present the resulting timeline divided into five-year periods.

Additionally, qualitative content analysis was performed on selected high-impact articles to extract nuanced insights into the challenges and solutions proposed for sustainable fisheries management. This involved coding and categorizing the main themes and recommendations discussed in the literature, providing a deeper understanding of the contextual factors influencing fisheries policies.

Ethical considerations were also considered during the review process, ensuring that the studies included met the ethical standards for research, particularly those involving human subjects and community-based participatory research. This is crucial for maintaining the integrity and credibility of the review.

4. RESULTS AND DISCUSSION

4.1 Preliminary data collection

A period of 10 years is considered relevant to understand the trend line regarding the applicability of the proposals developed by researchers. This also considers the relevance for the academic body in constructing knowledge that serves to provide solutions to an economic sector on which various communities depend. After a 2022 with scarce scientific publication due to the Covid-19 effect, the trend line for fishing cooperatives and mangrove care is positive due to the growing interest in including socio-ecological effects. The variable game theory is constant, and fishing quotas have more pronounced breaks resulting from the adjustments that each country makes to its region.

In analyzing the data in Figure 4, it is crucial to highlight the shifts in research focus that occurred throughout the decade. For instance, the early years saw a strong emphasis on maximizing economic yields and managing fish stocks through traditional means. However, as the decade progressed, there was a marked shift towards incorporating socio-ecological considerations into fisheries management. This shift is evidenced by the increasing number of studies that explore the integration of community-based approaches and the impact of environmental changes on fishery sustainability.

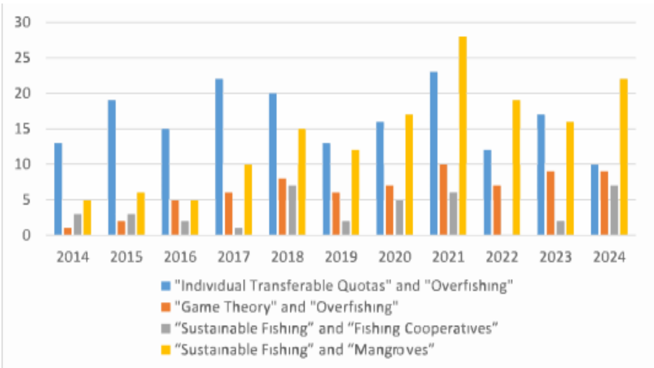

Figure 4. Number of publications 2014-2024

The data (Figure 5) shows that although environmental sciences predominate, research is increasingly an interdisciplinary work. It is notable that in various studies classified as environmental, there are articles with economic variables and vice versa. This indicates a fluid knowledge in fishing that tends to be increasingly integral.

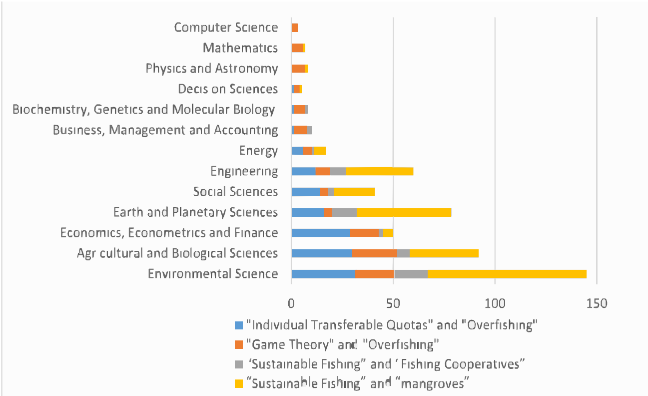

Figure 5. Thematic areas 2014-2024

Moreover, the collaboration between disciplines has led to the development of more holistic management strategies that consider the economic, social, and environmental dimensions of fisheries. This interdisciplinary approach is not only beneficial for creating more comprehensive management plans but also essential for addressing the complex and interconnected nature of fishery ecosystems.

4.2 Citation and productivity

Table 2 shows the 10 most cited authors. The most cited article corresponds to the thesaurus "quotas," titled "dynamic ocean management," which addresses the maritime resource as a fluid element where regions, species, and users are differentiated, and use rights such as dynamic and adaptive fishing quotas to the environment are needed [20].

An interesting observation from the citation analysis is the emergence of new influential authors and institutions over the decade. This reflects a dynamic research landscape where new ideas and approaches continuously challenge and refine existing paradigms. The increased citation of interdisciplinary studies also underscores the growing recognition of the importance of integrating diverse perspectives to tackle the multifaceted issues in fisheries management.

Table 2. Most cited authors

Year	Article	Author	Citation	Readers
2015	Dynamic ocean management: Defining and conceptualizing real-time management of the ocean. Maxwell et al. [20]	Sara M. Maxwell, Elliott L. Hazen, Rebecca L. Lewison, Daniel C. Dunn, Helen Bailey, Steven J. Bograd, Dana K. Briscoe, Sabrina Fossette, Alistair J. Hobday, Meredith Bennett, Scott Benson, Margaret R. Caldwell, Daniel P. Costa, Heidi Dewar, Tomo Eguchi, Lucie Hazen, Suzanne Kohin, Tim Sippel, Larry B. Crowder	329	611
2021	Blue growth and blue justice: Ten risks and solutions for the ocean economy. Bennett et al. [21]	Nathan James Bennett, Jessica Blythe, Carole Sandrine White, Cecilia Campero	173	570
2015	Neoliberalism and the politics of enclosure in North American small-scale fisheries. Pinkerton and Davis [22]	Evelyn Pinkerton, Reade Davis	129	219
2018	Viewpoint: Induced innovation in fisheries and aquaculture. Asche and Smith [23]	Frank Asche, Martin D. Smith	100	164
2018	A preliminary assessment of the indicators for Sustainable Development Goal (SDG) 14 “Conserve and sustainably use the oceans, seas and marine resources for sustainable development”. Virto [24]	Laura Recuero Virto	97	352
2016	Economic viability and small-scale fisheries — A review. Schuhbauer and Sumaila [25]	Anna Schuhbauer, U. Rashid Sumaila	88	309
2019	Rethinking power and institutions in the shadows of neoliberalism: (An introduction to a special issue of World Development). Karnad et al. [26]	Prakash Kashwan, Lauren M. MacLean, Gustavo A. García-López	78	243
2018	A call for a blue degrowth: Unravelling the European Union's fisheries and maritime policies. Hadjimichael [27]	María Hadjimichael	75	234
2014	Re-defining co-management to facilitate small-scale fisheries reform: An illustration from northwest Mexico. Finkbeiner and Basurto [28]	Elena M. Finkbeiner, Xavier Basurto	72	273
2018	Impacts and responses to environmental change in coastal livelihoods of south-west Bangladesh. Hossain et al. [29]	Mostafa A.R. Hossain, Munir Ahmed, Elena Ojea, Jose A. Fernandez	65	297

Table 3. Most productive authors

Author	University	Country	Cita	Document
Asche, Frank	University of Florida	EE. UU.	11505	253
Bennett, Nathan J.	University of Santiago de Compostela	Spain	8525	97
Maxwell, Sara M.	University of Washington Bothell	EE. UU.	3860	64
McClenachan, Loren E.	University of Victoria	Canada	3841	49
Pinkerton, Evelyn	University of Simon Fraser	Canada	3571	43
Finkbeiner, Elena Marie	Universsity of Stanford	EE. UU.	3529	2982
Ojea, Elena	University of Vigo	Spain	1799	1625
Kashwan, Prakash	Brandeis University	EE. UU.	861	40
Schuhbauer, Anna C.	University of British Columbia	Canada	717	717
Hadjimichae, María	Universsity of Chipre	Cyprus	431	393
Muawanah, Umi	Badan Riset e Inovasi Nasional	Indonesia	378	27
Russ, Jones	University of British Columbia	Canada	311	13
Virto, Laura Recuero	Pole Léonard-de-Vinci University	France	246	19
Quynh, Chi Nguyen Thi	University of Western Australia	Australia	131	7

Table 3 shows the data indicates that the countries among the top fish producers are also those generating the most research articles. Eight of the fifteen most cited authors are actively generating content mainly related to the environment and its effects on communities.

This geographic distribution of influential research highlights the global nature of fisheries challenges and the necessity for international collaboration. Countries with significant fishery industries tend to invest heavily in research to address both local and global fishery issues, contributing valuable insights and innovative solutions that benefit the broader scientific community.

4.3 Co-citation

Continuing with the author analysis, we present a network diagram (Figure 6) showing collaborations. It is possible to distinguish the working groups by thematic area.

The thematic areas of each working group, their orientation, and weight are identified from the network map according to the generated clusters.

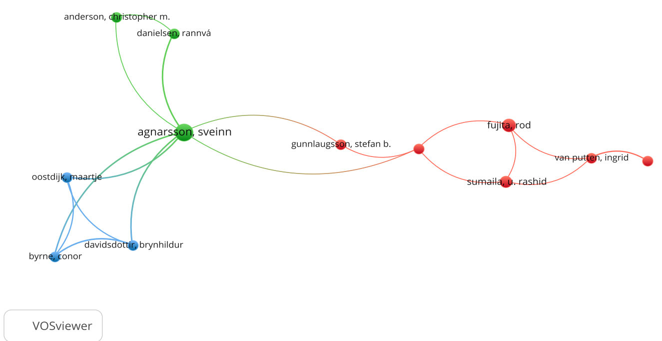

Figure 6. Co-author network map

The most influential author is Sveinn Agnarsson, who has collaborated on evaluations of fisheries policies. His most cited articles are developed in the case studies of Iceland, the main proponent of fishing quotas characterized by comprehensive regulatory systems and considered a success story.

Fishing quotas, although they form a study group, present endogenous dissimilarities. They are generally compared with other use rights strategies, and between countries, they show adaptations by region and species, so it is not possible to speak of a single thought scheme. As Stefan B. Gunnlaugsson indicates, sustainability persists but not consensus. This is why the predominant research groups focus on evaluations that provide consistent information for decision-making that maintains the balance between maximizing benefits and distributing common resources.

Table 4. Co-citation groups

Cluster	Author	Papers	Link Strenght
Cluster 1	Stefan B. Gunnlaugsson	3	3
	Rod Fujita	5	2
	Rashid Sumalia	4	3
	Ingrid van Putten	3	4
	Gakushi Ishimura	3	4
	Simon Vieira	3	2
Cluster 2	Sveinn Agnarsson	9	15
	Christopher M Anderson	3	2
	Rannva Danielsen	3	3
Cluster 3	Conor Byrne	3	8
	Brynhildur Davidsdottir	3	8
	Maartje Oostdijk	3	7

The co-citation analysis reveals several key insights into the structure and dynamics of research collaborations within the field of fishery sustainability. By examining the network of co-authors, in Table 4 we can identify influential researchers and research groups that drive the development of specific thematic areas.

The first group addresses the problems of fishery sustainability by considering the use rights under which it would be possible to redistribute wealth in a common-pool resource. They evaluate the strategy of fishing quotas from the perspective of cooperative participation and game models to make decisions related to economic arrangements and transboundary fish populations, which due to climate change, exhibit more erratic behaviors. Finally, they critique fishing quotas on the need to reinvent them to include socio-economic factors that translate into community well-being.

The second group generates content on risk assessments, performance indicators, and fishing policies. They conduct various case studies with positive results and emphasize the need to consider ecosystem-based approaches in quota calculations as they have demonstrated strength in maintaining biomass. The third group works collaboratively with Agnarsson, who serves as the linking author between the different clusters. Their greatest strength lies in evaluating fishing quotas. In 2024,

The idea that ITQs (Individual Transferable Quotas) present transitory gains, implying that in the long term they tend to be unsustainable. The results indicated a relationship of only 26%, suggesting that it is a functional system but only in a solid context and with the participation of fishers [30]. As demonstrated by Maartje Oostdijk, who explains that ITQs are weak in the face of financial instability because fishers will not respect quotas if their earnings cannot be guaranteed [31].

5. KEY CONCEPTS STRENGTH

5.1 Period from 2014 to 2019

As a result of the review of the filtered articles, a timeline in Figure 7 is presented with the evolution of the study of the fishing sector.

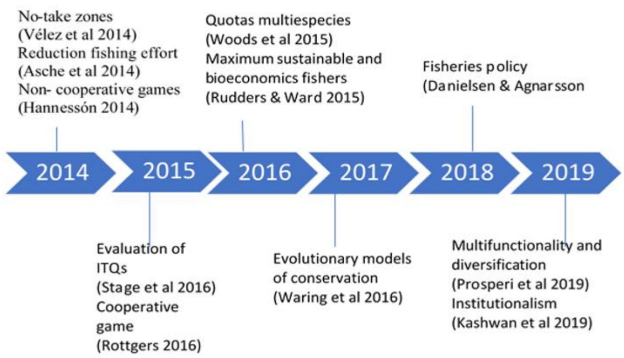

Figure 7. Timeline 2014-2019

In 2014, to address fishery collapses, the two most common strategies were marine closures and the reduction of fishing effort. Both strategies aimed to maintain economic yields but were unable to guarantee fishery reserves. Other studies indicate that many of the gaps lie in the non-compliance with agreements. To demonstrate this, a series of experiments related to non-cooperative game models were conducted, which essentially discuss the problems of achieving participation and joint effort that translate into sustainable levels.

By 2015, fishing quotas represented a balance between maximum yield and biomass conservation, with the idea of evolving towards a quota market. During this period, cooperative games were reviewed to explore the existence of explicit rules and strong leadership to achieve community participation.

Between the quota market and traditional quotas, multi-species annual catch rates emerged as capture mechanisms and limited quotas but with the elimination of discards, aiming to integrate ecosystem care. Various bioeconomic models were tested in case studies to achieve a balance between abundance and supply. The Gordon-Schaefer, Gram, and Copes models were applied to fishing activity [31], and evolutionary models also emerged to include social participation and institutions.

The case of the Faroe Islands, which has maintained five fishery management regimes: open access, regulated, fishing days, licenses, transferable quotas, and annual catch rates, narrates the difficulty in formulating fishery policies that balance fish populations, fishing effort, and employment objectives [32].

In 2018, the debate on neoliberalism and institutionalism raised the dilemma between the focus on wealth and well-being, discerning between the freedom to accumulate capital and the right to common-pool resources. Institutionalism could be the answer to changing power asymmetries and redistribution.

Ecological awareness in 2019 was integrated into the needs of fishery management under the non-productivity approach. The shift in resource use from exploitation to conservation (ecotourism) and multifunctional fishing (quotas) came to form a new package for future resilience.

5.2 Period from 2020 to 2024

Transitioning from the focus on yields to the integration of economic ecosystems, we enter the second study period, delineating a whole set of positions with defenders of both the maximum yield model and joint participation. In Figure 8, we can observe the different lines of thought in the research and their interrelationships. The Figure 8 review the effects of the policies studied during the 2020-2024 period; the literature review was divided by thematic area.

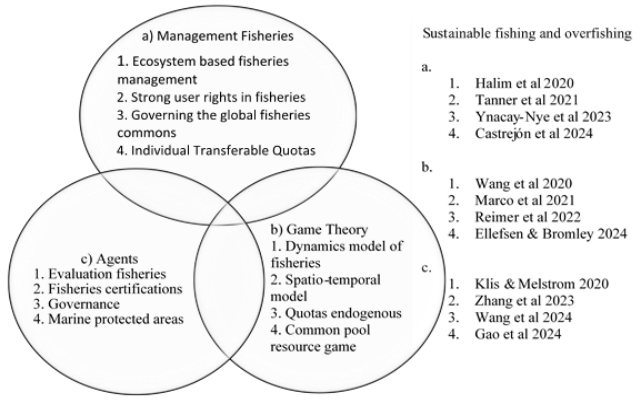

Figure 8. Vent diagram 2020-2024

In studies related to the participation of agents, evaluations of fish populations continue, but the effect of community intervention, including governance and voluntary trusts, is analyzed. They propose the use of certifications, a pro-environmental practice widely accepted by consumers, which can promote capture objectives based on quality rather than maximum catch.

Marine protected areas, known as capture zones, where all extractive activities are prohibited, gain momentum among proponents of ecological economics. They describe comprehensive spatial plans that include strict regulatory laws facilitating biodiversity conservation and community well-being by shifting their economic activities to recreational ecological zones [33].

Regarding fishery management, various dynamic models demonstrate the need to address common goods problems by considering different scenarios and practices. They highlight the need not to transform the fishing industry but to strengthen it through metrics based on endogenous factors for decision-making.

Decision-making game models become increasingly elaborate, with the main motivation being the number of participating agents and the variety of existing strategies. Games applied for sustainability are dynamic and reinforce the outcome of playing sequentially. Endogenous rates, sequential games, and agent-based models propose scenario evaluations for fishery management, with the coexistence of different policies and co-management being the trend.

Finally, common-pool resource models emerge, aiming to balance the sustainability of a social and economic ecosystem.

5.3 Strength of keywords

Using VOSviewer, it is possible to review the co-occurrence of the most frequently used keywords among different authors. In Figure 9, we observe the links between the most repeated words that form thematic groups and explain fishery sustainability.

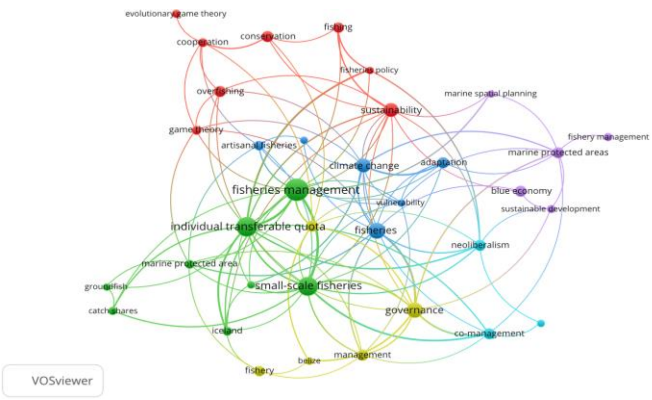

Figure 9. Keyword co-occurrence

Table 5. Keyword co-occurrence groups

Cluster	Keyword
Cluster 1	Conservation, cooperation, evolutionary games theory, fishing, game theory, overfishing and sustainability
Cluster 2	Catch shares, coastal management groundfish, Iceland, individual transferable quota, marine and protected area
Cluster 3	Adaptation, climate change, artisanal fisheries, Belize, fishery, food security and vulnerability
Cluster 4	Belize, fishery, governance, institutions, management
Cluster 5	Blue economics, fisheries management, marine protected areas, marine spatial planning and sustainable development

In Table 5, the first cluster addresses game theory as a tool to tackle the problems of overfishing and sustainability. In the second cluster, the keyword with the strongest link is transferable catch quotas, grouped with those that define fishery management, with Iceland being the reference for the application of quotas.

In the third cluster, actions related to climate change and its impacts on food security are included. In the fourth cluster, governance is identified as an effective means to manage fisheries, and in the last group, the emphasis is on marine protected areas to achieve sustainable development.

6. CASE STUDIES

Academics often insist on studying fisheries from an endogenous point of view due to their dynamic nature and the cultural factors of small-scale fisheries. Case studies are recurrent to explain and model strategies. The resulting map is only a reflection of the literature review; more in-depth studies are needed to observe the countries and policies not included in the study.

In Figure 10, we can observe the countries where experiments are conducted and the preferred fishery policy in each area.

It is interesting to note that there is no consensus on a single fishery policy. Each region, based on its ecosystem, commercial species, and prevailing socio-economic system, selects the appropriate strategy for the community. However, the prevalence of indicators that tend to performance metrics is also recognizable.

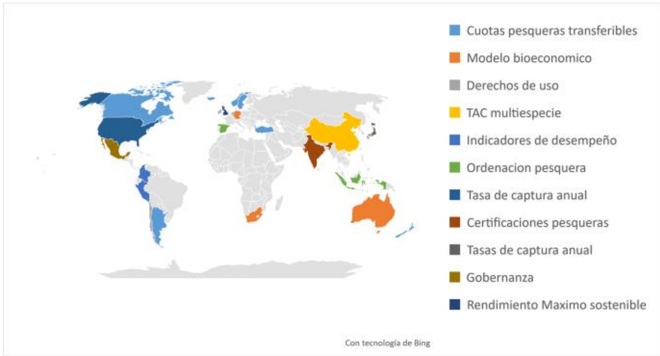

Figure 10. Case studies

For Mexico, governance remains the way to manage resources. The evidence suggests that it is feasible to bet on already proven models that reinforce existing regulation. Case studies show a strong fishery cooperative [34] where high levels of participation generate commitments for responsible ecosystem care [35].

7. CONCLUSIONS

The findings of this study reveal that transferable fishing quotas and the establishment of marine protected areas are fundamental tools to ensure the sustainability of fishery resources. It is essential that any implemented policy includes the participation of fishing cooperatives and considers regional particularities to be effective.

Additionally, it has been demonstrated that game theory is a valuable tool in decision-making, as it allows modeling various scenarios and cooperative strategies that improve the management of common resources. Collective action, supported by a robust institutional framework, has proven effective in enhancing economic benefits without compromising the sustainability of fishery ecosystems.

However, there is a recognized need to deepen the study of the specific impact of governance on improving quality of life and well-being indicators in fishing communities. Among the limitations of the present study is the dependence on secondary data and the need for more detailed case studies to validate the results in different contexts.

For future research, it is suggested to explore the effectiveness of transferable fishing quotas and marine protected areas in various ecosystems and socio-economic contexts. It is also crucial to investigate how community participation and collective action can be fostered through public policies and environmental education programs.

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