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Three-dimensional Sustainability Profile of the coastal fishery of Jalisco State, Mexico

Perfil tridimensional de la Pesquería en la Costa en el estado de Jalisco, México

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ABSTRAC

Sustainability is a basic tool in decision-making regarding human resources distribution for government programs applied to communities. The sustainability index reflects the level of impact on the effectiveness of its application. It is important to mention that a study of this nature has not been reported in the scientific literature for Mexican fishery activity on Jalisco Coast, Mexico. Thus, the results of this research will support the fishermen's federations in decision-making about their productive work. The main objective was to determine the sustainability index for Cihuatlán, La Huerta, Tomatlán, and Puerto Vallarta municipalities of Jalisco state, Mexico by applying the IRS methodology. Even when the productive activity is economically profitable, its do not contribute positively to the Social and Environmental sustainability indices. The index of the three-dimensional sustainability of the Jalisco Coast, Mexico fishing activity is 2,33, which is considered very low about what is desirable, which should be greater than 4. In other words, there is no positive development in the quality of life of fishermen and environment care for the catch areas and species of interest for commercial fishing activities.

Keywords: *Fisheries, Sustainability, Jalisco Coast, Environment, Social Quality, Economy.*

RESUMEN

La sustentabilidad es una herramienta básica en la toma de decisiones sobre la distribución de los recursos humanos para los programas de gobierno que se aplican a las comunidades. El índice de sustentabilidad refleja el nivel de impacto sobre la eficacia de su aplicación. Es importante mencionar que un estudio de esta naturaleza no ha sido reportado en la literatura científica para la actividad pesquera mexicana en la Costa de Jalisco, México. Así, los resultados de esta investigación servirán de apoyo a las federaciones de pescadores en la toma de decisiones sobre su labor productiva. El objetivo principal fue determinar el índice de sustentabilidad de los municipios de Cihuatlán, La Huerta, Tomatlán y Puerto Vallarta del estado de Jalisco, México, aplicando la metodología IRS (índice Relativo de Sustentabilidad). Aún cuando la actividad productiva es económicamente rentable, no contribuye positivamente a los índices de sustentabilidad Social y Ambiental. El índice de sustentabilidad tridimensional de la actividad pesquera de la Costa de Jalisco, México, es de 2.33, el cual se considera muy bajo de lo deseable, el cual debería ser mayor a 4. Es decir, no hay un desarrollo positivo en la calidad de vida de los pescadores y cuidado del medio ambiente para las zonas de captura y especies de interés para las actividades pesqueras comerciales.

Palabras Clave: *Pesquerías, Sustentabilidad, Costa de Jalisco, Ambiente, Calidad Social, Economía.*

Introduction

In recent decades, a strong awareness has been promoted about the economic, social, and environmental impact under the scope of sustainability for fisheries practices. This awareness has consequently brought the urgent need to make a change toward a fishery within the framework of sustainability. This change has allowed the development of different methodologies to evaluate the sustainability of marine species capture systems through different forms of weighting and analysis

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strategies. The methodology was developed by Casas *et al*. (Alvarez-Flores, 2020). makes it possible to determine the sustainability of fishing and capture activities in the Municipalities of Cihuatlán, La Huerta, Tomatlán, and Puerto Vallarta, Jalisco, Mexico that was obtained from the application of the Relative Sustainability Index (IRS in Spanish) methodology. The IRS assumes that Sustainable Development is only achieved from a certain level of development and integration of economic, social, and environmental indices.

The strategy development for the regional fishery to be carried out on the Jalisco state coast needs to quantify sustainability and identify key elements that will be considered appropriate for this study. Ideally, sustainability forms a triangle in which three dimensions concur in an integrated manner: a) economic, b) social, and c) environmental. Their values range from > 0.5 on a scale of 0.0 to 1.0. Values lower than < 0.5, according to the proposed scale, denote the absence of sustainability and the absence of contribution to these dimensions. These three dimensions allow us to determine the sustainability index for the commercial fishing activity carried out by fishermen on the coast of Jalisco state, Mexico. This index ranges from 0.0 to 5.0 and is determined by the mathematical equation proposed by Casas (Alvarez-Flores, *et al.*, 2020).

The project was carried out with the members of 3 Regional Fishing Cooperatives Federations. Each cooperative has a membership of approximately 20 to 30 members with a total of 1,520 associated fishermen.

The State of Jalisco-Barra de Navidad Coast Regional Fisheries Cooperatives Federation groups together 20 fishing cooperatives. The second is the Jalisco-Punta Pérula Regional of Cooperative Fisheries Production Societies Federation, with 6 fishing cooperatives. Finally, the Jalisco-Puerto Vallarta State Coast of Cooperative Fisheries Production Societies Regional Federation with 50 fishing cooperatives.

Methodology

For evaluating the sustainability of each municipality, the information of 36 family fishing production units was considered. The IRS methodology integrated three variables (dimensions) of different nature: social, economic, and environmental.

A questionnaire application containing a list of items about the productive activities of the interviewee was used. The list was divided into three sections, for each dimension or measurement (Economic, Social, and environmental). In addition, a semi-structured interview was conducted that aimed to delve into the answers given in the questionnaire.

A standardization process of the different variables was carried out to achieve a reliable instrument: economic as goods and technological and capital instruments to carry out their activities and the balance of their economic activities such as the sale of products obtained from fishing and the income-expenses balance.

Regarding the social dimension, characteristics such as human population, density, employment, health, food, education, migration, social, and political participation were considered.

Finally, environmental instruments were considered for the environmental dimension, such as ecological niches for collecting shellfish, the type of coast, biodiversity, management, and fishing area, and the fishing seasons, whether annual or periodic, at productive farms and productivity levels. It is important to mention that the fishing activities carried out by fishermen have artisanal characteristics with a commercial objective (for sale to restaurants and the public) and for self-consumption, but in no way do they have industrial characteristics. The fishermen only have individual or family catch units and use small 6–10-meter boats, small nets (less than 100 meters in length), and hook lines (above 100 meters in length). Fishermen are not characterized by using industrialized boats (factory boats) or deep draft boats (Lluch-Cota, *et al*., 2006).

This research was obtained from a diagnosis with the application of the Relative Sustainability Index methodology to be evaluated the information of at least 25 family fishing production units per federation of fishermen, and 18 variables under study were considered. With the application of the IRS, the sustainability and the contribution of the three mentions (environmental, social, and economic) in the members of the fishing communities were quantified. The diagnosis was complemented by the information obtained from 36 fishermen. This research was carried out in the municipalities of Cihuatlán, La Huerta, Tomatlán, and Puerto Vallarta, Jalisco, Mexico.

The goal of the project was to apply the questionnaire and interview at least 100 fishermen.

However, it was only possible to get 36 fishermen to participate. The researchers who carried out the fieldwork, when applying the questionnaire and the interview with the fishermen, detected that the main reason for their lack of participation and interest in providing the requested information was a consequence of distrust when sharing data, that fear the information may be misused, or simply because they were unaware of these.

Quantification and Qualification of Sustainability

The rating of each variable was related to its tendency towards sustainability and the location of the real average values in an interval which is established on a scale proposed by the evaluator, for example, from –5 to +5, and its limits are defined by the proportional interval (Xp), the minimum average value and the absolute maximum that the variable takes between the communities. In Table 1, the process and criteria for qualifying the variables are specified according to the behavior (positive or negative) of the average value among the communities. The trend towards sustainability among the variables is associated with their increasing or decreasing values and is related to the symbols > or <. Its trend can also be neutral, depending on the nature of the variable. The sustainability rating based on its trend is justified because there is no definition of the optimal technical levels of variables that lead to sustainable development. However, the trend relative to the desired behavior of a variable allows approximations to reach a needed level without defining its optimal value, and the criterion of its trend is based on common sense and basic knowledge of natural, economic, and scientific sciences.

Regarding the variables they were selected by discriminant functions, then standardized and rated according to their sustainability trend on a scale of 1 to 5.A series of equations were proposed to quantify the contribution of each variable in its dimension and each dimension to sustainability; for this purpose:

$$C_{kt} = \frac{V_{ikt}}{I_{kt} * e} \quad (1)$$

Where: C_{kt} = the contribution of the kth dimension or attribute to the IRS at the t time; I_{kt} = the number of variables or indicators of the k dimensions or attributes at time t; kt = the dimensions or attributes at time t; V_{ikt} = the value of the i-th indicator on the Likert scale, where: i = 1, 2, 3, ... I_{kt}. k = 1, 2, 3, ... kt. y, t = 1, 2, 3, ... T; e = absolute maximum value of the V_{ikt} Likert scale, and IRS_t = relative sustainability index at time t.

The Likert scale is a discrete evaluation scale that the evaluator proposes to convert natural values into classes; These classes are whole natural numbers that might vary from -5 -a +5.

The equation estimates the contribution of the dimensions (C_{kt}) for the region and per community, while the second and third estimate the IRS for the region and communities between –1 and +1. As the IRS measurement is a weighted average of the contribution of the dimensions, this value is higher than 0.5 when there is sustainability demonstrating

Table 1. Transformation and qualification of the real values of a variable continues a discrete scale, using five ranges, according to their tendency to promote (+) or inhibit (–) sustainability.

	Interval Condition if the averages:		
Variable Rating Interval	They are positive and the trend is positive +	They are negative and the trend is positive, or the trend is 0	They are positive and negative with a positive trend
Score = ± 1	X ≤ X(1) + Xp	X>X(5) – Xp	X≤ 0± Xp
Score = ± 2	X(1) + Xp > X ≤ X(1) + 2XP	X(1) + 3Xp > X ≤ X(1) + 4Xp	± Xp > X ≤ ± 2Xp
Score = ± 3	X(1) + 2Xp > X ≤ X(1) + 3Xp	X(1) + 2Xp > X ≤ X(1) + 3Xp	± 2Xp > X ≤ ± 3Xp
Score = ± 4	X(1) + 3Xp > X ≤ X(1) + 4Xp	X(1) + Xp > X ≤ X(1) + X p	± 3Xp >X ≤ X ± 4Xp
Score = ± 5	X> X(5) – Xp	X≤ X(1) + Xp	X > X(5) ≠ Xp

Note: † X is the value of the variable under evaluation in each community; X (1) is the lowest absolute value of the evaluated communities that the variable takes; X (5) is the highest absolute value that the variable has in the communities, and Xp is the proportional part of the evaluation space of the variable divided by five (X (5) X (1))/5.

the integration of the dimensions. On the contrary, IRS values less than 0.5 show a lack of development and integration of the dimensions and indicate a lack of sustainability (Casas *et al*., 2009).

Description of the study subjects

In Mexico, there are between 300,000 and 350,000 fishermen, of which 90 percent are artisanal fishermen. One of the most important characteristics of this type of fisher is that they resort to the delimitation and appropriation of fishing areas, which are usually managed through community arrangements (Arreguín-Sánchez F., 2006; Mendivil-Mendoza, 2018).

Fishing cooperatives have historically been characterized by being many but very disorganized (Villaseñor A.S. & R. García de Quevedo M., 1990).

The study was carried out on fishermen in the different localities of the Jalisco Coast, from the city of Cihuatlán to the city of Puerto Vallarta. The subjects to whom the questionnaire was applied belong to one or another of the different Fishing Federations existing on the Jalisco Coast. These federations are made up of two or more Fishing Cooperatives.

A total of 36 fishermen/seafood vendors were interviewed. Of the total, 28 belong to the Barra de Navidad Fisheries Federation, 2 belong to the La Huerta Federation, 3 to the Puerto Vallarta Federation.Finally, three subjects did not declare a federation affiliation.

The subjects who participated in the study were distributed in the following cooperatives: Cooperativa Los Frailes: 18 fishermen; Cooperativa Punta Farallón: 6 fishermen; Cooperativa Rivera Melaque: 4 fishermen; Cooperativa Manahuita de Vallarta: 4; Fishermen and Pacific Divers: 2 and finally, 2 fishermen did not answer which fishing cooperative they belonged to, respectively.

From the total of the fishermen interviewed, 32 were men and 4 women. The ages of the fishermen ranged from 20 to 80 years, with a Mean = 48.83 years old; S.D. ± 14.20.

Their marital status was distributed as follows: Single: 12; Married: 16; Divorced: 2; Widowed: 1, Free Union: 1; Finally, 4 did not answer about their marital status, respectively.

Of the total number of fishermen and people linked to the activity of the fishery who were interviewed, 34 were fishermen and 2 of seafood sellers.

Results

Economic Profile

Annual catch

The subjects who were interviewed were distributed by the number of people who contribute economically to the family economy as follows: from one to two people who contribute economically to the family: 21 fishermen; from 3 to 5 people: 9; more than 5 people: 5 fishermen, respectively.

Regarding the number of men who contribute economically to the family, out of a total of 36 interviewees, the distribution is as follows: a single man: 25; two men: 7; 3 men: 1, and finally, 3 did not answer the question.

In the case of the number of women who contribute economically to the fishermen's family, the distribution is as follows: one woman: 7; two women: 3; three women: 1, five women: 1; and finally, 24 do not contribute financially to the family.

The fishermen interviewed who receive a weekly income (US dollars) are distributed as follows: income of $24.00 (equivalent to $ 1,152.00 per year): 5 fishermen; With an income of $48.00 ($ 2,304.00 per year): 24; With an income of $95.00 ($4,560.00 per year): 3 interviewees; and finally, with an income of $143.00 or higher ($6,864.00 per year): 3 interviewees, respectively.

Financing of Fishing Activity

Of the total of fishermen interviewed, 34% of them reported having received a financial credit from a Savings Association; 14% and 11.4% from a bank. The rest did not answer where they got their credit. Regarding the query of whether the credit obtained had been sufficient for their financial needs, 94% answered yes, and 6% answered negatively. The financial resource was used for the purchase of fishing equipment 11%, for the capture of shellfish 31.5%, and for other purchases, 20%. The rest of the fishermen interviewed did not report how they used the resource.

Limitations for commercialization

The main limitations for commercializing seafood and fish products when fisherman offers their product to the market are the Quality of the Products 34.3%

and the lack of Organization in the sale 28.6%. The rest of the fishermen interviewed did not reply.

Fishermen reported an average annual combined catch of 3.59 tons, S.D. ± 4.56, including all fish species of commercial interest, with a minimum of 1.0 tons and a maximum of 14.0 tons.

The average annual price for fish species is USD 3.33 per kilogram. The average annual price of seafood is USD 8.00 per kilogram.

Thus, the average annual gross income for fishermen's boat crew from fishing activities is USD 46,670.00. Moreover, the income from seafood is USD 32,400.00.The average annual combined gross income for each boat crew of fish and seafood caught is USD 38,000.00. For each captain, the annual income is USD 76,200.00, and finally, each crew member is USD 19,000.00.

In 2012, De los Santos-Cruz & Torres-Solis [4], reported that the gross income of 49% of the artisanal fishermen interviewed on the coasts of Chiapas, Mexico is USD 34,320.00-54,860.00 and for 51% of the fishermen is less than this. Thus, the income reported by the fishermen of the Jalisco Coast can be considered higher compared to those reported in the study conducted in Chiapas, Mexico.

It is important to note that the amounts of income and expenses were given in Mexican pesos (1.00 US dollars = 21.00 Mexican pesos in December 2021).

Social Profile

Housing

Regarding the description of the social profile of the interviewees, the results obtained are as follows: the average house occupation (number of people living in the house) is 4.40 inhabitants per house; S.D. ± 16.47. The average number of men living in the house is 2.01; S.D. ± 0.639. Furthermore, the number of women living in the house is 1.51; S.D. ± 1,336.

Food

Regarding the weekly consumption of food, soft drinks, and cigarettes, the results obtained are shown in Table 2.

In Table 2, it is possible to see that the consumption of nutritious foods is lower than the consumption of soft drinks, cigarettes, juices, and bread. This diet indicates limited nutrition and high consumption of non-nutritive products, and the consumption of cigarettes and soft drinks stands out.

Table 2. Average weekly consumption of food and other products by fishermen and their families.

	Min	Max	Mean	S.D.
Fruit and Vegetable	1.00	5.00	2.677	1.739
Beff and Pork	1.00	6.00	3.033	1.217
Chicken	1.00	6.00	3.100	1.422
Beans	1.00	5.00	2.400	1.673
Fish	1.00	5.00	2.580	1.232
Milk	1.00	5.00	2.612	1.606
Softdrinks	1.00	6.00	3.400	1.8112
Cigarettes	1.00	6.00	4.958	1.829
Juices	1.00	6.00	3.709	1.829
Bread	1.00	6.00	3.323	1.399

The food consumed by the fishermen and their families is an average weekly expenditure of USD 29.00; SD ± 20.22 with a maximum of USD 710.00 and a minimum of USD 5.00.Fishermen and their families spend on clothing each week an average of USD 12.00; S.D. ± 18,030. With a minimum of $5.00 and a maximum of USD 95.00.

In Health, fishermen and their families spend per week an average of 10.40 dollars; DE ± 25.99. With a minimum of 0.00 and a maximum of $ 95.00.

Finally, the weekly education expenditures made by fishermen and their families average are 14.07 dollars; S.D. ± 40.09; with a minimum of 0.00 and a maximum of USD 190.50.

Combined, the average weekly expenditure of fishermen and their families is USD 63.00; S.D. ± $ 96.04, that is, $132.00 per month; equivalent to USD 1,584.00 annually with a minimum of $12.00 and a maximum of USD 452.00.

The Housing quality of fishermen and their families is characterized by having the basics of drinking water, drainage, and electricity services. They also have the basic furniture for the house.

The fishermen and their families interviewed reported that in the case of a health situation, they go to the IMSS (Mexican Institute of Social Security); 80.0%, SSA (Secretary of Health and Assistance); 11.5% and a Private Physician 6.0%, 1.5% did not answer. The IMSS and SSA are government health agencies.

Environmental Profile

Fish and Seafo od

The fish species that fishermen generally catch in an average year are varied and mostly depend on

the season of the year, the fishing equipment that the fishermen have, their experience, the market demand, and the presence of the fish in the fishing areas.

SeaFood. Octopus (*Octopus hubbsorun*), Crab or Ganifos (*Callinectes arcuatus*), Oyster (*Crassostrea prismatica*), Queen Clam (*Peryglipta multicostata*), Estero Shrimp (*Farfantepenaeus californiensis*, *Litopenaeus vannamei*), and Lobster (*Panulirus gracilis*, *Panulirus gracilis*) (Aguilar, B. *et al.*, 2011).

Fish. Red snapper (*Lutjanus peru*), Sarangola (*Microlepidotus brevipinnis*), Flemish snapper (*Lutanus guttatus*), Sierra (*Scomberomorus sierra*), Chana (*Haemulon flaviguttatum*), Goat (*Epinephelus analogus*), Mojarra rayada (*Gerres cinereus*), Cook (*Caranx caballus*), Sorrel Snapper (*Lutjanus argentiventris*), Horse Mackerel (*Caranx caninus*), Tiger (*Cirrhitus rivulatus*), Snook (*Centropomus nigrescens*), Curvina (*Umbrina xanti*), Palmeta (*Trachinotus rhodopus*), Puerco o cochito (*Balis polylepis*), Cazón (*Carcharhinus falciformis*) and Yellowfin Tuna (*Thunnus albacares*), respectively (Aguilar, B. *et al.*, 2011; Espino-Barr E. & M., Cruz-Romero, 2006).

The size of the fish caught differs as various criteria are applied for their sale. Thus, restaurants prefer fish of 300.00 to 500.00 grams since these are the ones that are served in the dishes that they offer to their customers. Fish that do not meet this criterion, whether of smaller or larger sizes and weights, are sold to vendors in local and regional markets, and in the cities closest to the fisherman's residence.

Fishmen and Crew Description

On the one hand, the crew team for seafood catch is commonly made up of two fishermen; the driver of the boat (who acts as captain and is generally the owner of the boat and the fishing equipment) and a worker; who is the one who catches the seafood and puts it on the boat.

On the other hand, the fishing crew team consists of 3 fishermen; the driver of the boat (it is the same case described above) and 2 workers, who carry out the activities of deployment of nets or lines of hooks, their extraction from the sea, and the recovery of the fish trapped on the net.

Fishing Income Description

After subtracting the operating expenses, the net income from the fish sale is generally distributed as follows; 50% for the boat owner and the other 50% for the rest of the crew members.

Sustainability Profile

Generally, fishermen do not carry out selective fishing; that is, they fish everything caught in their nets (some fishermen use the net known as "Diablera," prohibited by Mexican law since it has different sizes ranging from 1 to 4 inches, and they catch all kinds of fish). Another illegal practice is the use of "Hook Lines," which contain different sizes of hooks and which are set at different depths. Fishermen do not return to the sea what is not of commercial interest, or if it is the case, they use it for the next catches as bait, and the same happens with the capture of shellfish.

It is important to mention that each year, by law, there are different ban seasons for each species of fish and shellfish. These bans can vary from 3 to 7 months, although the average is 5 months (De los Santos-Cruz, A. & Torres-Solís, S., I. 2012; Villaseñor A., S. y R. García de Quevedo M., 1990). The fishermen who are dedicated to artisanal fishing do not respect these closures.

Although during the interviews, exceptions could be detected among the interviewed fishermen who are also perceived as aware of the legal fishing regulations and apply them daily in their fishing activities.

As is shown in Table 3, the three dimensions: economic, Social, and Environmental are being calculated with the following values: 0.4735, 0.2701, 0.0935, respectively. The results in the Table 3 shows that the higher value is the economic and the lower is environmental. Thus, the IRS calculated is 0.233 of all three combined dimensions and finally, the sustainability contribution is 8.83.

Table 3. Evaluation of the sustainability and the Contribution of the Dimensions for the Sustainable Development of the fishing activity of the Jalisco Coast, Mexico, based on statistical data.

	Fishery Activity
Economic	0.4735
Social	0.2701
Environment	0.0935
IRS	0.233
% of sustainability Contribution	8.83

Conclusion

The highest economic income reported by fishermen (captains) is USD 38,100.00, which is added to the annual income of the other members of the family, which is USD 5,238.00 (reported weekly income $ 101.60; S.D. ± 0.36). In the case of support fishermen, their annual salary is USD 24,500.00. This high annual family economic perception is very high for the socioeconomic standards of the South Coast of Jalisco, Mexico.

However, the use of the resources obtained by the fishing activity is not focused on the maintenance or improvement of the quality of life of the fisherman or their families. The lack of knowledge in family income administration means that these economic resources are used mostly in social activities such as parties and superfluous purchases. Thus, productive activity tends to be a survival activity. The Economic Sustainability index is rated as 4.

Regarding the social sustainability index, some family members have higher education; 3% only. Although, their education level might consider as low since fishermen have very low levels of education, where more than 50% only have completed primary education and, on average, only have completed 3rd grade of elementary education. However, some cases were reported in which the fishermen are illiterate. The lack of environmental education aimed at sustainable fishing is a determining factor in productivity. The Social Sustainability index has been rated as 2.

Finally, since the questionnaire and interviews were not detected or reported by the fishermen of any environmental care activities, regarding the Environmental Sustainability index, it is considered less than 1.

In summary, the sustainability index of the Jalisco Coast, Mexico, fishing activity is scored as 2.33. Which is considered very low concerning what is desirable; more than 4 (Arreguín-Sánchez F., 2006).

Even when the productive activity is economically profitable, they do not contribute positively to the Social and Environmental sustainability indices. In other words, there is no positive development in the quality of life of fishermen, and neither are the catch areas and species of interest for fishing activities (Alvarez-Flores, *et al*., 2020; Vázquez-León, C.I., 2006).

A possible explanation for the results obtained in this study is because this productive activity has been considerably influenced by the historical misunderstanding of the Mexican government, which led to the lack of support and development programs for the Mexican fishery (Aguilar, *et al*., 2011; Alcala, G., 2003).

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