Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

Article

Social Vulnerability of The Fishing Community to Restrictive Public Policies: Case Study Gulf of Ulloa, Mexico

Diaz-Santana-Iturrios, B.[1], C.A. Salinas-Zavala[2], I. Sánchez-Brito[1] and M.V. Morales-Zárate[2*]

[1] Universidad Autónoma de Baja California Sur. Carretera al Sur KM 5.5, 23080. La Paz, B.C.S.
[2] Centro de Investigaciones Biológicas del Noroeste, S.C. Av. Instituto Politécnico Nacional 195. Col. Playa Palo de Santa Rita Sur. 23096. La Paz, B.C.S. México.
* Correspondence: author: mzarate04@cibnor.mx

Abstract. The social vulnerability approach (SV) has set up that social inequalities and disadvantages have gone beyond monetary poverty in the last years, since the process is built at different scales. In its objectives, the SV multidimensional measurement is contemplated as a priority tool to monitor the compliance of the first goal – eliminate poverty in all its forms. Therefore, the objective of this research is to calculate the SV of the fishing communities of the Gulf of Ulloa (GU), Mexico by macro-markers to subsequently contrast them with field micro-data, and finally perform a behavior scenario, considering the current public policies restrictive to fishing in such areas. The results showed significant differences depending on the type of information used, obtaining a contingency coefficient of 83.42%, which indicates that the calculus depends strongly on the data used and suggesting that macro-data may be masking the true SV values in the area, in such a way they could be severely underestimated. Even though the context at micro-scale is not the only one, SV should be calculated to analyze the fishing communities since coastal fishery represents almost the total livelihood of the inhabitants. Nevertheless, these communities confront numerous local and global threats, and these pressures on SV put their livelihoods, well-being, food security and traditional lifestyle at risk. Therefore, the role of researching human dimensions and governance is not only basic but also urgent to turn to sustainable socioeconomic management.

Keywords: Social vulnerability; Public policies in coastal fisheries; Gulf of Ulloa

1. Introduction

Social vulnerability (SV) regularly refers to the potential negative effects on communities caused by external human health stresses, which include natural or human-caused disasters or disease outbreaks. Reducing social vulnerability can decrease both human suffering and economic loss. However, the SV approach has set up that social inequalities and disadvantages have gone beyond the monetary poverty in the last years, since it is a process built at different scales that combines different levels. For example, micro-level are strategies and availability at home; meso-level are organizations, institutions, and macro-level are social structure, market, State. In the objectives of sustainable development, the SV multidimensional measurement contemplates the initiative that marks the global agenda up to 2030, which includes this type of measurement as a priority tool for monitoring compliance of its first goal: eliminate poverty in all its forms (PNUD, 2015).

From the perspective of socioenvironmental systems, the main sources generating SV are socioeconomical, such as poverty, lack of education, precariousness of housing, gender inequity, productive chain disintegration, abuse of intermediaries; corruption of governmental and private agents, overexploitation of some resources, and precariousness of productive infrastructure (Ivanova and Gámez, 2012). Much of this social vulnerability is a reflection of the level of education and organization of the same communities, which -particularly for fishery communities- derives from fundamental factors, such as operational capacity limitation and consequently income decrease (Sumaila *et al*., 2011).

Despite the importance that SV studies of rural communities have gained in the last years, their evalution is performed based on qualitative or semiqualitative methods that regularly use secondary sources of data instead of gathering primary data, which do not capture political or ecologica factors that affect vulnerability levels of the community (Lavoie *et al*., 2018).

Therefore, the objective of this research is to calculate social vulnerability of the fishery communities of the Gulf of Ulloa (GU) by general markers to subsequently contrast them with field information at local level, and finally perform a behavior scenario, considering public policies restrictive to fisheries that are currently maintained in such area.

2. Material and Methods

2.1. Study area

The Gulf of Ulloa (GU) is located in the western coast of the Baja California peninsula, aproximately between 25º and 27º N and 112º and 114º W (Figure 1), which is completely influenced by the California Current (CC) (Lynn and Simpson, 1987; Bograd and Lynn, 2001), and its southern limit adjoins the Bahía Magdalena-Almejas Lagoon system. During reflux, the gulf provides elevated concentrations of organic and phytoplankton material toward the adjacent ocean (Aguíñiga, 2000). These attributes make the GU to be considered as a *Biological Action Center* (BAC).

The high production values in the gulf favor the presence of different fishery resources in such quantities tha have maintained the most important fishery in the entity contributing to approximately 25% of all artisanal fishery in the state of Baja California Sur (BCS) (Lluch-Belda *et al*., 2000). Exploitation in this area is around 100 species distribuited in some resources of great volume and low cost, such as small pelagic (sardines and mackerel) or those in low volume but great commercial market value, as lobster, abalone, shrimp, and many others in less quantitiy, but they sustain the fishery activity in the area (Lluch-Cota *et al*., 2006). Coastal fishery in the region is very important for the economy of the state and inhabitants of local communities, generating direct employment and in many cases the only economical activity of its inhabitants. This region has approximately 21 fishery localities that add up to 7,940 inhabitants and a total of 1,228 fishers. For the purposes of this research, 16 of the 21 localities recorded were considered. All these localities are rural type except for Puerto San Carlos (Figure 1, Table 1). From this population, approximately 13% show high marginalization levels because they lack water, electricity, health and education services, and the rest, 87% show medium marginalization levels (INEGI, 2010).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

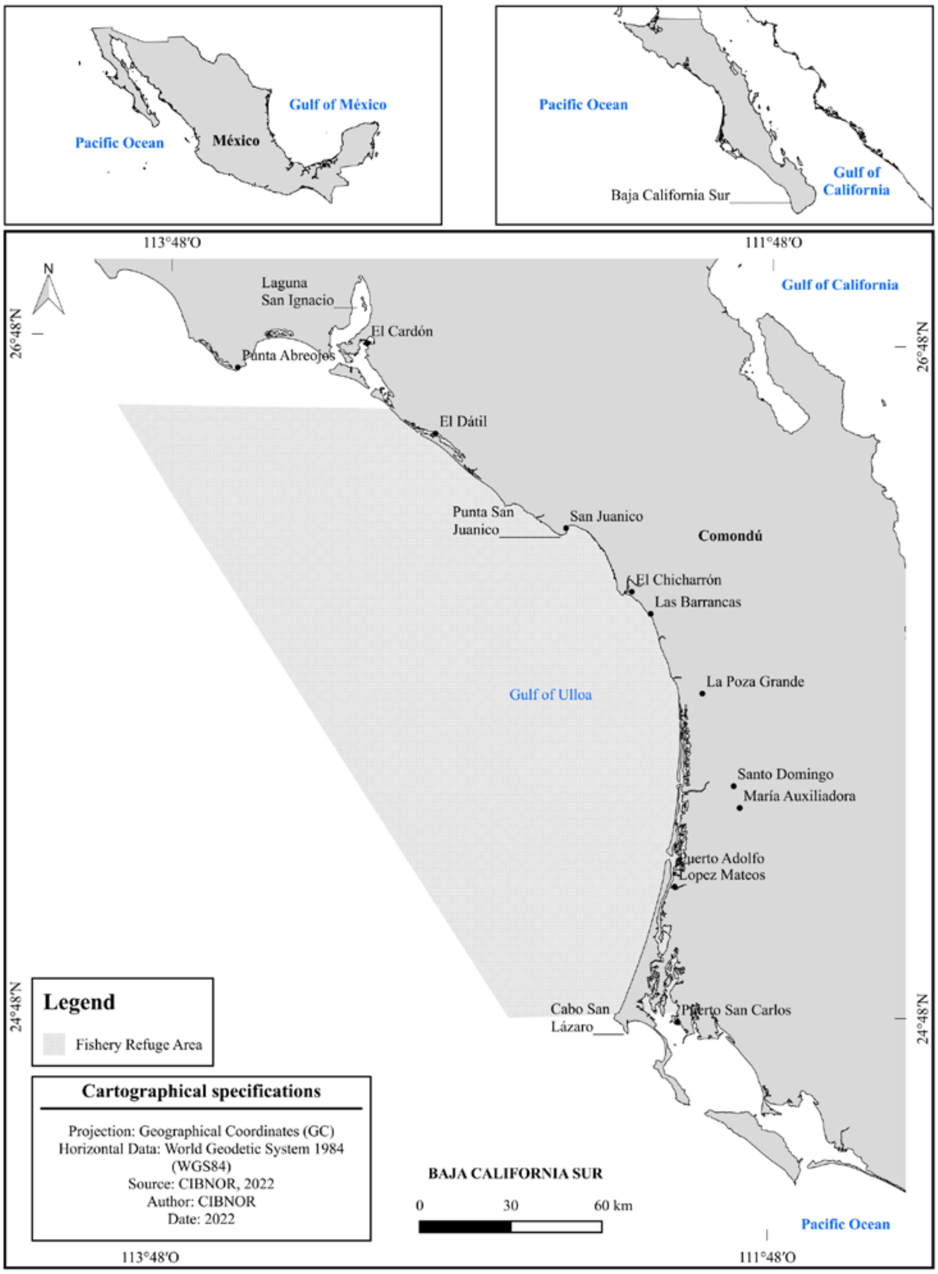

Figure 1. Area of study. Geographical location of the Gulf of Ulloa in the western coast of the state of Baja California Sur, Mexico. The main fishery localities bordering the polygons considered when the Fishery Refuge Area was implemented.

Table 1. Localities of the Gulf of Ulloa fisheries contemplated in this study; number of fishers in each one of them and number of surveys applied per locality in Baja California Sur, Mexico.

	Locality	Number of fishers	Surveys performed
1	El Chicharrón	65	11
2	La Poza Grande	102	15
3	Las Barrancas	122	17
4	María Auxiliadora	25	7
5	Puerto Adolfo López Mateos	372	52
6	Puerto San Carlos	17	11
7	San Juanico	100	14
8	Santo Domingo	86	13

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

9	La Base	3	5
10	Ejido Luis Echeverría	14	5
11	El Cardón	75	12
12	El Dátil	84	12
13	Campo Delgadito	46	8
14	La Freidera	22	1
15	La Laguna	2	6
16	Punta Abreojos	93	17
	Total	**1228**	**206**

Deriving from fishery resource heterogeneity in the GU, competent authority has implemented different management strategies from traditional measures, such as minimum capture size (e.g. lobster), fishing gear limitation (shrimp), permit concesion (clams) up to more elaborated methods, such as management by administrative areas (sargassum) or with annual capture quotas per species, size, season and area (e.g. abalone). However, as in all highly productive marine ecosystems, the GU is also a concentration area of species that are not subjected to fishing. Some of them may even be species under any type of especial protection, such as marine mammals and sea turtles.

In this context, as a consequence of the turtle mortality observed in the surrounding areas of the GU starting from 2003 and facing with international pressure, the GU was declared a Fishing Refuge Area (FRA) because of the interaction between coastal fishing and the yellow loggerhead sea turtle *Carettta caretta* in April 2015. These measures were initially implemented for two years (DOF, 2015) and subsequently, the agreement was modified extending the restriction area (DOF, 2016). Then in 2018, it was modified again extending its existing period to five more years (DOF, 2018), in such a way that it is currently in force, restricting the main productive activity in the region. It is worth to mention that for many inhabitants in the area, artisanal or coastal small-scale fishery (SSF) (general term for multispecific fish) is the only economic activity that can be developed. Thus, the need to evaluate the SV of the communities as direct users of this type of fishing resources facing the restrictions since these administrative measures limit the only source of employment for the general village population.

2.2. Social Vulnerabity Index calculus

Deriving from the lack of consensus on the SV concept, its calculus is difficult without a well-defined multiscale and conceptual framework. In this sense, a great variety of methods exists to evaluate it, and the majority are expressed as indexes focused mainly on community response in the face of natural threats. However, for the objectives of this study, no method was found considering SV facing sociopolitical threats. Therefore, the proposal of the National Center for Disaster Prevention (CENAPRED for its acronym in Spanish) that is the governmental organism in charge of performing research on origin, behavior and consequences of natural and anthropogenic phenomena causing disasters was used. The results of this proposal have a bearing on developing technology, identifying danger, decreasing risks in alertness and disasters, consequently, regular consultancy for decision-making and public policy design (CENAPRED, 2014). The method to calculate the social vulnerability index (SVI) proposed by CENAPRED hereafter named Macro-social vulnerability index (Macro-SVI), has a municipal maximum spatial resolution scope and uses mainly secondary sources of data.

The Macro-SVI has three components: (C1) socioeconomical; (C2) prevention and response capacity; and (C3) local risk perception. These components have a weighting of 50%, 25%, and 25%, respectively, as shown in Equation 1.

$$Macro-SVI = (C1 * .50) + (C2 * .25) + (C3 * .25) \quad (1)$$

Where:

Macro-SVI = Social vulnerability index at macro scale

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

C1 = Result of the socioeconomical component
C2 = Result of the capacity and prevention response component
C3 = Result of the local risk perception component

2.3. Calculus of C1 or socioeconomical component

The socioeconomical component includes 18 variables grouped in five categorías: health, education, housing, employment and income, and population. Each variable has its measurement range described in CENAPRED (2014). Vulnerability values are from 0 to 1, where 1 corresponds to the highest vulnerability level and 0 to the lowest one. Once the vulnerability value of each variable is established, an average for each category is obtained, and those of the categories is the value of the socioeconomic component.

To calculate the component of the socioeconomical variables, data were taken from the 2010 Population and Housing Census from INEGI (Censo de Población y Vivienda 2010, Instituto Nacional de Estadística y Geografía); the State and Municipal Database System (Sistema Estatal y Municipal de Base de Datos, INEGI, 2010); and the 2016 Statistical Yearbook of the Health Ministry (Anuario estadístico 2016 de la Secretaría de Salud) of Baja California Sur.

2.4. Calculus of C2 or Prevention and response capacity

To calculate prevention and response capacity, CENAPRED (2014) uses a set of 24 close-ended questions with a Yes/No response and an assigned value of 0 for Yes and 1 for No. In the macroscale, all the values of this component were made equal to 0 since at municipal level, all the responses were YES, in other words, the municipality has the prevention and response capacity facing the risk situations contemplated.

2.5. Calculus of C3 or Local risk perception

This component refers to an imaginary joint action on environmental threats that exist in the community and the degree of the population exposure. However, in many occasions the population does not have a clear perspective of the danger that a natural or anthropomorphic threat in their locality represents, which has a direct bearing on the response capacity facing a disaster or restrictive instruction by the authority.

To calculate local risk perception at macroscale, the CENAPRED (2014) method proposea a set of 25 questions whose values are from 0 to 1. Considering that the risks of natural phenomena are the most frequent in the GU, this study took 10 questions that generally identify the perception that local fishers have about these risks. These questions were also used at microscale, which are dealt with in the next section. The quantification of this component by locality was made by adding the total of the surveys standardizing the values from 0 to 1 by applying the normalization method MIN-MAX (Han, *et al*, 2005) to the values obtained and assigning the corresponding category pointed out in Table 2.

Table 2. Social vulnerability scale for the local risk perception in the surroundings of the Gulf of Ulloa.

Category	Very high	High	Medium	Low	Very low
Local risk perception value	0.8 – 1.0	0.6 – 0.79	0.4 – 0.59	0.2 -0.39	0 – 0-19

2.6. Calculus of Social Vulnerability Index at microscale (Micro-SVI)

With the purpose of obtaining information at local scale in the area of study, the SVI calculus previously mentioned was performed but using timely information taken in

 doi:10.20944/preprints202207.0205.v1

field through *ad hoc* semistructured surveys. The instrument is divided in three sections focused on (1) general and socioeconomic aspects of the interviewee; (2) fishery activity and perception on the established regulation measures in the area; and (3) climate variability aspects (Appendix I). The number of surveys per locality are shown in Table 1.

2.7. Fishing restriction scenario

Finally, a scenario of decreasing money supply -deriving from the restriction in economic activity- was calculated. For this purpose, a model based on ECOPATH with ECOSIM (EwE; http://www.ecopath.org) trophic relationships was developed for the demersal-pelagic system of the GU and used (Morales-Zárate, *et al*., 2021). For this purpose, the action of two forcing agents in the ECOSIM module was combined: (1) Increase of 3 °C in sea surface (SST) over the average recorded in the California Current based on the forecasts reported by the Intergovernmental Panel on Climate Change for the area of study (Ivanova and Gámez, 2012) and (2) Elimination of the fishing line and gillnet fishery effort as established in the decree of the Fishery Refuge Area (DOF, 2018). The simulation went on for 30 years with annual cuts. The average simulated captures per year were compared with those obtained in the last 10 year and their equivalent in constant weight were calculated, finding an annual average percentage decrease that was substracted from the socioeconmical component of the Micro-SVI.

2.8. Statistical calculus and spatial representation of social vulnerability of the fishery communities of GU

With the three SVI calculus per locality an associated analysis of nominal variables was performed by means of a contingency table (3 x 5) and the statistical chi-square (x^2) to subsequently calculate the contingency coefficient according to equations (2) and (3).

$$C = \sqrt{\frac{X^2}{(X^2+n)}} \quad (2)$$

$$MaxC = \sqrt{\frac{Min(r-1,c-1)}{1+Min(r-1,c-1)}} \quad (3)$$

where
C = Contingency coefficient
$MaxC$ = Maximum theoretical coefficient
X^2 = Chi square value
n = Sample size
r = Number of contingency table rows
c = Number of contingency table columns

Finally, the SVI values per locality obtained in the three calculi – macroscale, microscale, and simulaton scenario – were represented in isolineal maps, using the inverse distance weighting (IDW) with a power of 2 contained in the Quantum GIS (QGIS) versión 3.4 Madeira program.

3. Results and Discussion

The results of Macro-SVI indicate that social vulnerability for the fishery communities of the GU are found within the low or very low categories (Figure 2).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

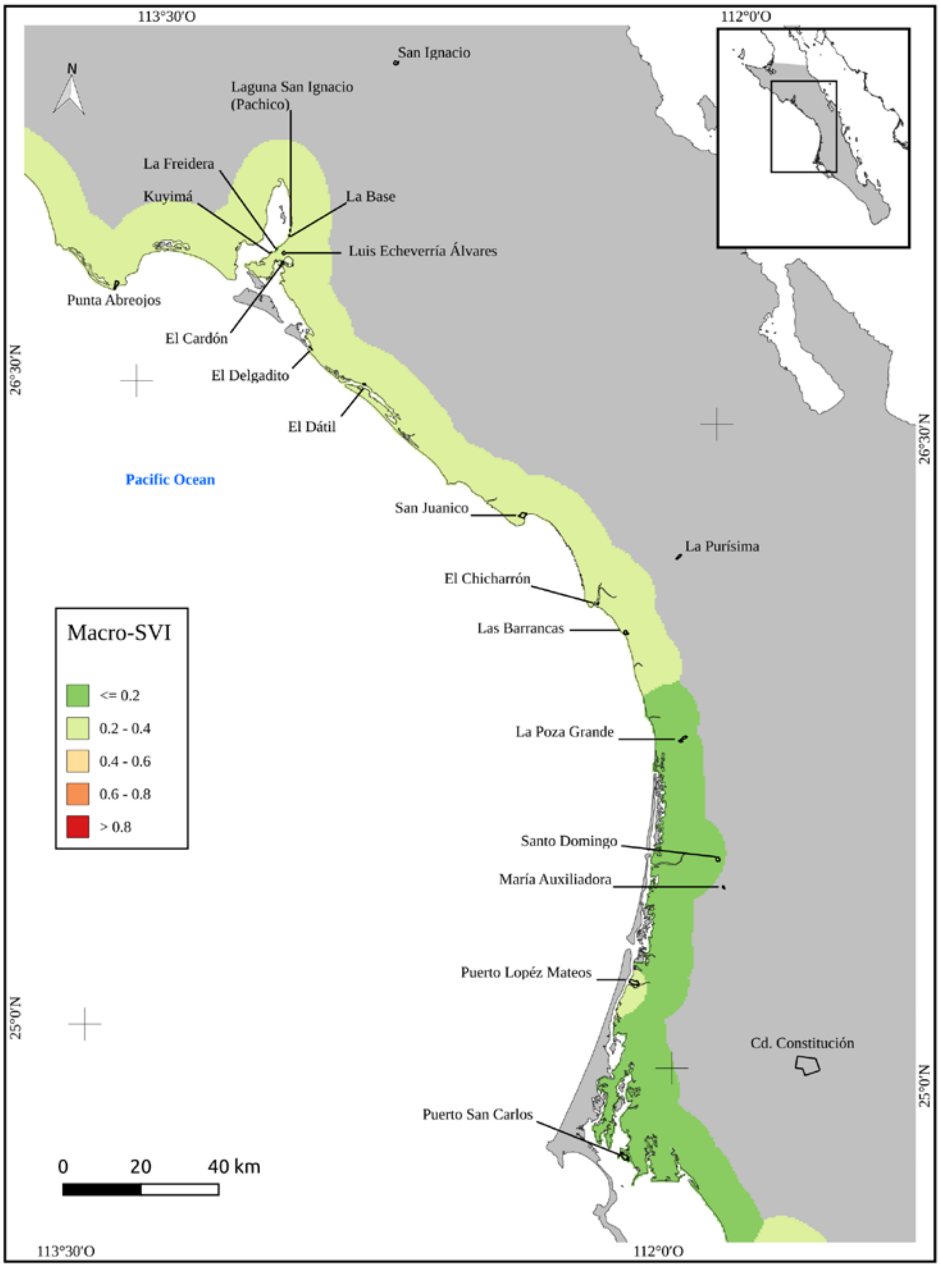

Figure 2. Macro-social vulnerability index (Macro-SVI) spatial expression for the fishery communities of the Gulf of Ulloa, Baja California Sur, Mexico, considering secondary source information.

However, the results of Micro-SVI show social vulnerability increases beyond the medium and high social vulnerability in 14 out of 16 localities, of which only the communities of La Freidera, La Poza Grande, and Puerto López Mateos remain in low values (Figure 3). Nevertheless, considering SVI for the economic income reduction scenario due to the restriction in the use of gillnet and line fishing, the rest of the 14 communities passed from high to very high SV values with the exception of the communities of La Freidera and La Poza Grande (Figure 4).

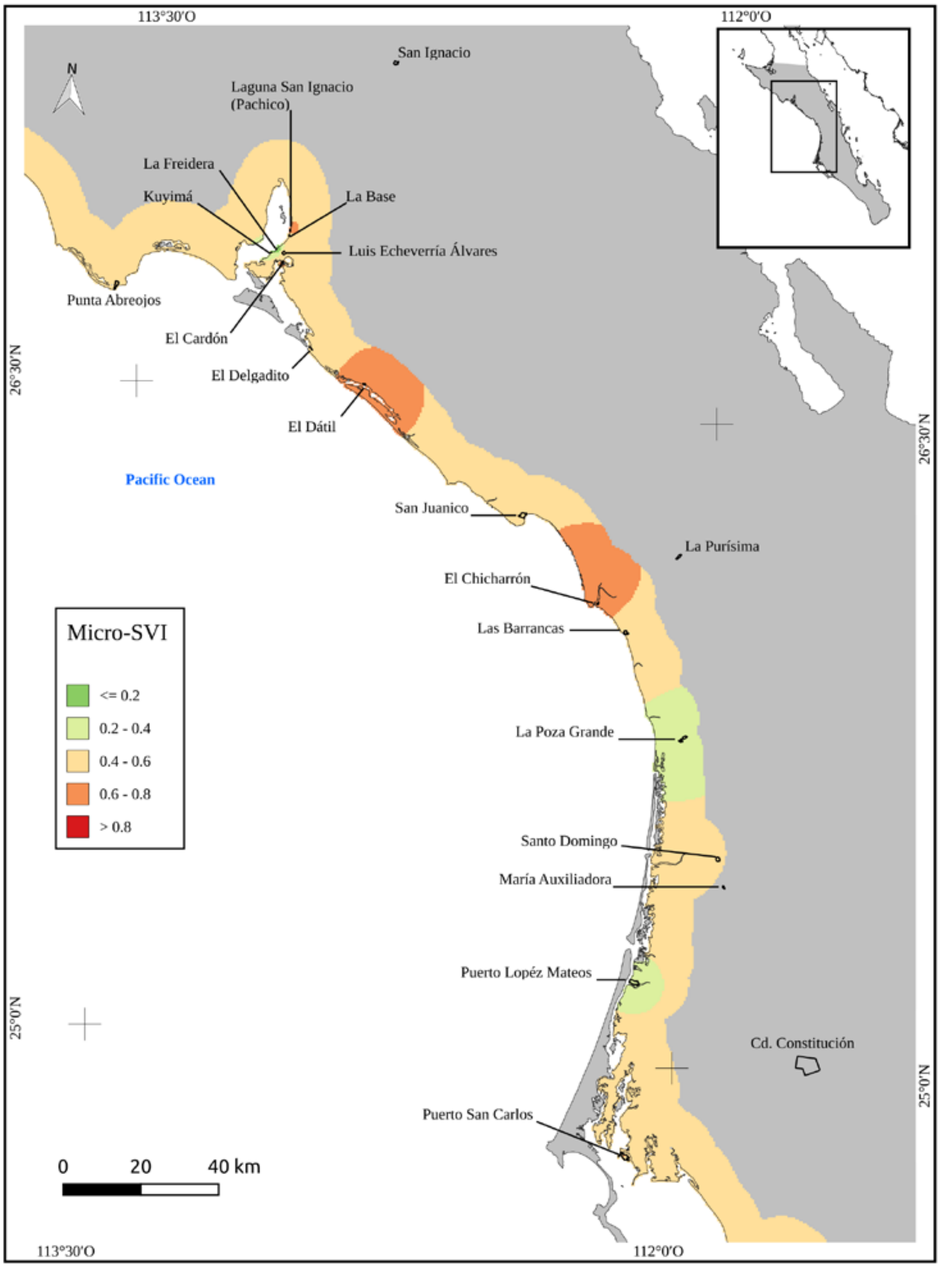

Figure 3. Micro-social vulnerability index (Micro-SVI) spatial expression for the fishery communities of the Gulf of Ulloa, Baja California Sur, Mexico considering primary source information acquired on site.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

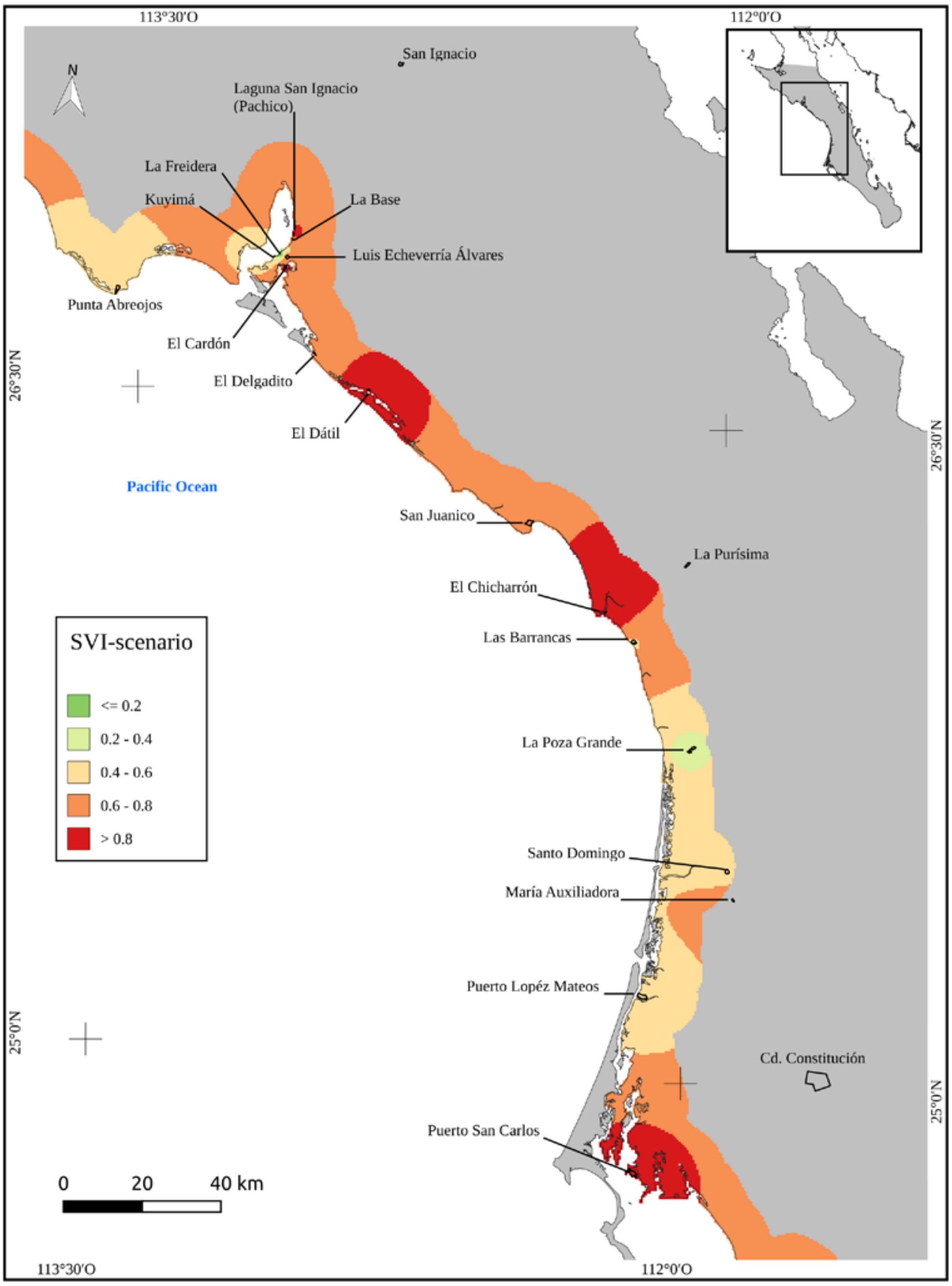

Figure 4. Spacial expression of the social vulnerability index-scenario for the fishery communities of the Gulf of Ulloa, considering primary source information taken on site.

With respect to the contingency table deriving from the Macro-SVI, Micro-SVI and SVI th scenario calculi, Table 3 shows the results of $X^2_{0.05,8} = 41.53 > 15.5073$ rejecting H_0, that is, the model used for the SVI calculus has an influence on the results obtained. Thus, the differences are not random products. Additionally, the coefficient of the maximum

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 July 2022 doi:10.20944/preprints202207.0205.v1

contingency indicates how strong the reltionship between the two variables is, which is 83.42%. Therefore, a statistically significant relationship exists between the social vulnerability level and the model used.

Table 3. Contingeny Table for social vulnerability (SVI) calculus for fishery communities in the surroundings of the Gulf of Ulloa off Baja California Sur, Mexico.

	Number of localities by catergory					
Model	**Very low**	**Low**	**Medium**	**High**	**Very high**	**Total**
MACRO-SVI	6	10	0	0	0	**16**
MICRO-SVI	1	2	9	4	0	**16**
Scenario-SVI	1	1	4	5	5	**16**
Total	**8**	**13**	**13**	**9**	**5**	

The concept of social vulnerability is used in different disciplines and, to date to our knowledge, no consensus exists on its meaning, even though coincidence has been identified in some of them. For example, the socioeconomical context grants relevance to SV as determinant in its capacity to confront and reciover from extreme events; the presence of a threat is recognized; the concept clarifies it is not a synonym of poverty nor margination but integrates both and adds the capacity of the population to confront such threats (Soares, 2010). In general terms, SV may be understood as the susceptibility of a community to suffer harm facing external factors due to their internal characteristics that make them incapable of confronting the threat and recover from harm; strictly speaking, it is a concept opposite to resilience. Adger (2006) proposed that research on vulnerability conveys the development of solid and credible measures, incorporation of methods that include risk perceptions and governance research on the mechanisms that mediate vulnerability, promote adaptive action and resilience and provide support for consilience and integration. For a truthful understanding of social vulnerability and measure its intensity, parameters or thresholds should be established to indicate starting at what point or what the conditions are that generate important damage or loss (Ruiz, 2011). Clearly humans are an integral part of marine socioecological systems. Changes in these ecosystems impact human communities and, viceversa, changes on human communities impact marine ecosystems. Therefore, the interactive nature of these systems is the key to understanding and governance (Perry *et al*., 2010). Vulnerability indexes have been designed in the fishery environement, whose purpose is to evaluate change in coastal management to help anticipate and mitigate SV (Silva *et al*., 2019). Due to the complexity and speed of environmental and sociopolitical changes in marine coastal systems, a profound academic interest exists to evaluate and promote the adaptation capacity of the fishery communities (Whitney *et al*., 2017).

With respect to the method used, some annotations should be made. The SVI proposed by CENAPRED (2014) is a tool to make comparative evaluation of social vulnerability among municipalities with respect to natural danger. The method considers the socioeconomical characteristics of the population, its response capacity and local risk perception. The method describes the markers and components that integrate the index and shows justifications for each one. However, in general, no solid arguments are expressed to justify the selection of markers, weight allocation for each one and for the components, nor for their integration.

Based on the results obtained, the Micro-SVI model reflects more precisely the conditions in which the fisher community of the GU live because the information used for its calculus is timely and not masked with municipal information that could convey a subestimation, as observed clearly in the fishing sites of Adolfo López Mateos, El Chicharrón, El Dátil, La Poza Grande, and Puerto San Carlos.

Nevertheless, considering the lack of income scenario due to the restrictive measures applied to fishing, the vulnerability degrees are high and very high, of which the most affected localities are Ejido Luis Echeverría and El Cardón. In the socioeconomical component, the highest vulnerability levels were with respect to housing and employment and income. On the one hand, this result was due mainly to the lack of acces to water and drainage services, as well as to the material from which their houses are built. On the other hand, the percentage of the population economically active who receive income of at leas two minimum wage salaries is the condition reached based on the simulated scenario.

In literature the discussion is that the SVI result is affected by the subjectivity of decision making for each step of its design, from the selection of the variables to the method to integrate them (Füssel, 2009; Tate, 2012; Hinkel, 2011). In some occasions these subjective decisions are not justified or only vaguely (Tate, 2012). Although a certain degree of subjectivity is required in any modeling exercise, its effects in the results should be taken into account before decision-making or formulating strategies based on such results (*Ibidem*).

The index proposed by CENAPRED, as many others, generates results that allow making comparison between different units of anlysis or also making comparisons in time. Thus, units can be defined as more or less vulnerable than others, and also evaluate if any implemented strategy to decrease vulnerability in a certain area has provided the desired effect. Nevertheless, points of reference are not established for the majority of the markers, from which significant changes are generated in the populations. For example, the housing deficit marker shows inconsistencies described in the methods that should be taken into account when using this method for other evaluations.

Although certain social conditions that make the weak population structure exist and make them vulnerable to a wide range of threats (poverty, minority status, and age), certain elements make the communities more vulnerable facing certain type of risks (CPRA, 2017). For example, the access to safety housing conditions could acquire more relevance if social vulnerability is evaluated when facing natural risks, such as earthquakes or hurricanes. Thus, defining the weight of each one of the model subcomponents is important in function of the risk or threat for which a vulnerability analysis should be performed.

Nonetheless, the results produced in this study with the adaptations performed in the second model (Micro-SVI) serve as a baseline, as well as to evidence that the model as originally planned (Macro-SVI) may not be reflecting the real conditions of the timely or microscale analysis. According to Lavoie et al (2018) the community vulnerability indexes are useful tools for a fast evalution. However, they should be validated and supplemented with ethnographic data before their implementation as management and political formulation tools or else it could lead to wrong decision making that potentially generates high socioenvironmental costs. To understand what makes marine socioecological systems resistant or vulnerable in a world of growing uncertainties requires natural and social collaboration efforts of scientists, users, resource adminstrators, and the community in general (Perry *et al.*, 2010)

This research study indicates that the context of microscale if not the only one, it is determinant to calculate social vulnerability in the analyzed fishery communities, since coastal fishing represents almost the totality of their inhabitants livelihoods. However, these communities confront numerous local and global threats, and pressures on SV endanger their livelihoods, well-being, food security and traditional life styles. Therefore, the role of reseach in human dimensions and governance is not only a priority but also ugent to retake the course of a sustainable socioenvironmental management.

Acknowledgments: This research was performed with partial financing of the projects: 263341 of the Environmental Sectorial Research Fund (Fondo Sectorial de Investigación Ambiental) and the Proyect A1-S-43455 of the Sectorial Research Fund for Education (Fondo Sectorial de Investigación para la Educación) in Mexico. All the authors are grateful to CIBNOR technicians: Jorge Angulo Calvillo, Enrique Calvillo Espinza, Andrés Peralta and René A. Kachok Gavarain for their support in field data gathering; to Diana Fischer for English edition; and to anonymous reviewers.

 doi:10.20944/preprints202207.0205.v1

References

1. Adger, W. N. (2006). Vulnerability. Glob. Environ. Change, 16(3), 268-281.

2. Aguíñiga, S. 2000. Aspectos de la geoquímica del material orgánico en el BAC del Golfo de Ulloa Baja California Sur. En: Lluch-Belda, D., J. Elordy – Garay, S.E. Lluch-Cota and G. Ponce-Díaz. BAC Centros de Actividad biológica del Pacífico Mexicano. CIBNOR. CICIMAR-IPN, CONACYT. 356 p.

3. Bograd, S. J. and R. J. Lynn. 2001. Physical-biological coupling in the California Current during the 1997 – 99 El Niño-La Niña cycle, Geophys. Res. Lett., 28, 275 – 278.

4. CENAPRED. Centro Nacional de Prevención de Desastres. 2014. Serie Atlas Nacional de Riesgos. Guía Básica para la Elaboración de Atlas Estatales y municipales de Peligro y Riesgos. Evaluación de la Vulnerabilidad Física y Social. Secretaría de Gobernación. 166 p.

5. CPRA. Coastal Protection and Restoration Authority. 2017. Louisiana's Comprehensive Master Plan for a Sustainable Coast. Investing in our future building a coastal protection and restoration strategy for the next 50 years. Committed to our coast. 184 p.

6. DOF. Diario Oficial de la Federación. 2015. ACUERDO por el que se establece una zona de refugio pesquero y medidas para reducir la posible interacción de la pesca con tortugas marinas en la Costa Occidental de Baja California Sur.

7. DOF. Diario Oficial de la Federación. 2016. ACUERDO por el que establece la zona de refugio pesquero y nuevas medidas para reducir la posible interacción de la pesca con tortugas marinas en la costa occidental de Baja California Sur.

8. DOF. Diario Oficial de la Federación. 2018. ACUERDO por el que se amplía la vigencia del similar por el que establece la zona de refugio pesquero y nuevas medidas para reducir la posible interacción de la pesca con tortugas marinas en la Costa Occidental de Baja California Sur, publicado el 23 de junio de 2016.

9. Füssel, H. M. 2009. Review and quantitative analysis of indices of climate change exposure, adaptive capacity, sensitivity and impacts, Background Note to the World Development Report.

10. Han, J., Pei, J., & Kamber, M. (2012). Data mining: concepts and techniques. Elsevier, 3th Edition, 740 p.

11. Hinkle, J. 2011. Indicators of social vulnerability and adaptative capacity: towards a clarification of the science-policy interface. Global Environmental Change 21:198-208. DOI:10.1016/j.gloenvcha.2010.08.002

12. INEGI. Instituto Nacional de estadística Geografía e Infrmatica. 2010. Censo Poblacional y de Vivienda. Subsistema de Información Demográfica y Social. En Línea: https://www.inegi.org.mx/programas/ccpv/2010/.

13. Ivanova A., and A. Gámez (Eds). 2012. Plan Estatal de Acción ante el Cambio Climático para Baja California Sur. UABCS, CIBNOR, CICESE, CICIMAR-IPN, SEMARNAT, CONAYT, INE, Gobierno de Baj Salifornia Sur. 120 p.

14. Lavoie, A., K. Sparks, S. Kasperski, A. Himes-Cornell, K. Hoelting and C. Maguire. 2018. Ground-truthing social vulnerability indices of Alaska fishing communities, Coastal Management, 46:5, 359-387, DOI: 10.1080/08920753.2018.1498710

15. Lluch-Belda, D., M. Hernández-Rivas, R. Saldierna-Martínez and R. Guerrero-Caballero. 2000. Variabilidad de la temperatura superficial del mar en Bahía Magdalena, B.C.S. Oceánides, 15: 1-23.

16. Lluch-Cota D. B. and S. Hernández-Vázquez (Eds). 2006. Desarrollo Sustentable de la Pesca en México: Orientaciones Estratégicas. Senado de la República, México, ISBN970-727-072-1., 446 pp.

17. Lynn, R. J. and J. J. Simpson. 1987. The California Current System: The Seasonal Variability of Its Physical Characteristics. Journal of Geophysical Research: Oceans, 92, 12947-12966. DOI.org/10.1029/JC092iC12p12947

18. Morales-Zárate, M.V., J.A. López-Ramírez and C.A. Salinas-Zavala. 2021. Loggerhead marine turtle (*Caretta caretta*) ecological facts from a trophic relationship model in a hot spot fishery area: Gulf of Ulloa, Mexico. Ecological Modelling. Volume 439 (1). DOI.org/10.1016/j.ecolmodel.2020.109327.

19. Perry, R.I., R.E. Ommer, E.H. Allison, M-C. Badjeck, M. Barange, L. Hamilton, A. Jarre, R.A. Quiñones & U.R. Sumaila. 2010. "Interactions between changes in marine ecosystems andhuman communities," pp. 221–251. In book: M. Barange, J.G. Field, R.P. Harris, E.E. Hofmann, R.I. Perry & F.E. Werner (eds.) Marine Ecosystems and Global Change. Oxford: Oxford University Press, pp. 407

20. PNUD. Programa de las Naciones Unidas para el Desarrollo. 2015. Panorama general. Informe sobre Desarrollo Humano. Trabajo al servicio del desarrollo humano. Communications Development Incorporated, Washington DC, EE.UU. 48 p.

21. Ruiz, N. 2011. La definición y medición de la vulnerabilidad social. Un enfoque normativo. Investigaciones Geográficas. Boletín del Instituto de Geografía 77: 63-74.

22. Silva, M. R. O., M. G. Pennino, and P. F. M. Lopes. 2019. Social-ecological trends: managing the vulnerability of coastal fishing communities. Ecology and Society 24(4):4. https://doi.org/10.5751/ES-11185-240404

23. Soares D., R. Romero, and R. López. 2010. Índice de vulnerabilidad social en Atlas de vulnerabilidad hídrica en México ante el cambio climático, Martínez Austria, Polioptro F. y Carlos, Patiño Gómez (editores), SEMARNAT, IMTA, México, pp. 9-16.

24. Sumaila, U. R., W. W. L Cheung, V. W. Y. Lam, D. Pauly and S. Herrick, S. 2011. Climate change impacts on the biophysics and economics of world fisheries. Nature Climate Change. 1-8.

25. Tate, E. 2012. Uncertainty Analysis for Social Vulnerability Index. Annals of the Association of American Geographers. 103:3. Pp. 526-543. DOI: 10.1080/00045608.2012.700616.

26. Whitney, C. K., N. J. Bennett, N. C. Ban, E. H. Allison, D. Armitage, J. L. Blythe, J. M. Burt, W. Cheung, E. M. Finkbeiner, M. Kaplan-Hallam, I. Perry, N. J. Turner, and L. Yumagulova. 2017. Adaptive capacity: from assessment to action in coastal social-ecological systems. Ecology and Society 22(2):22. https://doi.org/10.5751/ES-09325-220222