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MODELING OF INDICATORS FOR EVALUATION THE SUSTAINABILITY OF ARTISANAL FISHING IN THE SURROUNDING OF THE NATIONAL FOREST IBURA, NORTHEASTERN BRAZIL

ABSTRACT

Brazil is the holder of the greatest biodiversity on the planet, and can not shirk regarding the development of monitoring templates related to nature conservation and sustainable use of natural resources. In this sense, this research aimed to develop a model for evaluating indicators based on the methodology MESMIS (Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales incorporando Indicadores de Sustentabilidade) for use in its level of fishing communities or extractive related to protected areas, based on the existing community of fishermen in the surrounding National Forest Ibura, Brazil. The MESMIS the methodological basis was chosen for model development and evaluation indicators. Descriptive statistics analyzed censitariamente (N=100) with the minimum (MIN), medium (MED), desirable (P75), and maximum (MAX). The resulting model consists of 14 sustainability indicators that meet the attributes: (a) productivity, (b) stability, resilience and reliability, (c) adaptability, (d) equity, (e) self-management. It is possible to conclude that there is technical feasibility and to develop mathematical models of sustainability assessment systems based on indicators. When reviewed in complex revealed that artisanal fisheries developed in the analyzed system has a Relative Sustainability Index (IRS) of 26%. The results also demonstrated that it is possible to reach an IRS=33% based on the local situation (P75).

KEYWORDS: Sustainability Indicators; MESMIS; Artisanal Fisheries; Extraction; Conservation Units; Protected Areas.

MODELAGEM DE INDICADORES PARA AVALIAR A SUSTENTABILIDADE DA PESCA ARTESANAL DO ENTORNO DA FLORESTAL NACIONAL DO IBURA, NORDESTE DO BRASIL

RESUMO

O Brasil é detentor da maior biodiversidade do planeta, e não pode se esquivar no tocante ao desenvolvimento de modelos de monitoramento relacionados à conservação da natureza e uso sustentável dos recursos naturais. Neste sentido esta pesquisa teve como objetivo desenvolver um modelo de avaliação de indicadores baseado na metodologia MESMIS (Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales incorporando Indicadores de Sustentabilidade) para sua utilização em nível de comunidades de pescadores ou extrativistas relacionados com Unidades de Conservação (UCs), tomando por base a comunidade de pescadores artesanais existente no entorno da Floresta Nacional do Ibura, Brasil. O MESMIS foi a base metodológica escolhida para desenvolvimento do modelo e avaliação dos indicadores. A estatística descritiva analisou censitariamente (N=100) os parâmetros mínimos (MIN), médios (MED), desejáveis (P75), e máximos (MAX). O modelo resultante é composto por 14 indicadores de sustentabilidade, que atendem os atributos: (a) produtividade; (b) estabilidade, resiliência e confiabilidade; (c) adaptabilidade; (d) equidade; (e) autogestão. É possível concluir que existe viabilidade técnica e matemática para desenvolvimento de modelos de avaliação de sustentabilidade de sistemas baseado em indicadores. Ao serem analisados de forma complexa revelaram que a pesca artesanal desenvolvida no sistema analisado tem um Índice Relativo de Sustentabilidade (IRS) de 26%. Os resultados demonstraram ainda que é possível alcançar um IRS=33% baseando-se na realidade local (P75).

PALAVRAS-CHAVE: Indicadores de Sustentabilidade; MESMIS; Pesca Artesanal; Extrativismo; Unidades de Conservação.

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INTRODUCTION

Since 2002, it has been noticeable the fragility of the international events and agreements, because there have been many discussions but little have been done effectively by nations. Sustainability concept is difficult to be defined and further to be put in practice with coherence (MASERA et al., 2008). Economic development concerns allied to the world economic crisis made nations stepping back from signed deals. Many proposals discussed along this period require complex and multidimensional actions, that is, not to be attached to the Cartesian thinking for solving problems, and able to involve combined actions of several dimensions.

Globally, especially in Europe, new tools (models) able to transform theoretical notions of sustainability into practical concepts are available (SINGH et al., 2009). These decision-making models are essential to orientate productive systems for sustainability (HANSEN, 1996), for example artisanal fishery, extraction and agriculture. However, communities that live in systems for nature conservation need more orientations about how better they can change their practices, so that these tools will be effective. Sustainability indicators are tools that can be used by these communities at local or regional level, to evaluate the effects of the changes caused by intervention actions (PANNELL & GLENN, 2000).

There is a wide range of indicators debated on scientific literature. Deepening the understanding and analysis of sustainability of dynamic and multidimensional systems, it is perceptible the appearance of vices and difficulties, from under the conceptual to the methodological view (MASERA et al., 2008). Most models of indicators measure agricultural systems, individually or through comparison. Some pieces suggest that is it better to develop a group of indicators for evaluating specific systems of scientific production (MEUL et al, 2008; VAN CALKER et al, 2005). Freebairn and King (2003), for example, say in their piece that indicators depend upon the context, scale and objective of the analysis, while Zhen and Routray (2003) propose that an analysis method must be linked to the context of the specific agricultural systems.

The result obtained from these tools not always provides an easy use and understanding by the target communities, being restrictively used by government specialists and scientists interested in indicators methodology. A graphic representation of radar type allows a wide vision of indicators for the different aspects of sustainability (BOCKSTALLER et al, 1997; GOMEZ et al, 1996; RIGBY et al, 2001). In Vermont University (USA), a group of researchers adapted a model that evaluates agricultural sustainability through self-assessment, from the Dairy Farm Sustainability Toolkit (BYLIN et al., 2004), where sustainable practices are interpreted as indicators (MATTHEWS, 2010).

In 1994, the MESMIS (*Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales incorporando Indicadores de Sustentabilidade*) came to sight in Mexico when the Rockfeller Foundation decided to invest in one method capable of evaluating sustainability for systems of natural resources. The studies derived from this investment were carried out by the

Grupo Interdisciplinario de Tecnologia Rural Apropriada (GIRA), the Centro de Investigaciones em Ecossistemas de la UNAM, the Colégio de la Frontera Sur and the Centro de Investigacion em Ciencias Agropecuarias de la UAEM (MASERA et al., 2008). Until 2008, about 40 case studies which applied the MESMIS for evaluating the systems of natural resources had been catalogued.

Under this issue, the objective of this study was to develop an evaluation model of indicators based on the MEMIS methodology (*Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales incorporando Indicadores de Sustentabilidade*) for being used by fishermen´s or extractors´ communities related to Conservation Units (CUs), considering the existing community of artisanal fishermen in the surroundings of the National Forest Ibura, Northeastern Brazil.

Indicator Concept

According to Van der Werf and Petit (2002), an indicator is a variable which reflects or explains the most difficult of understanding and quantifying phenomena or facts. According to Mitchell et al. (1995), an indicator is an alternative measure model used to describe a state or situation where direct measurements are not possible. Indicators can be used individually, as part of a group, or aggregated in one model or tool to increase comprehension by the interested communities and managers (VAN PASSEL et al., 2007). The three main functions of an indicator are: simplification, quantification and easy communication. Indicators offer several functions, mainly politics elaboration and evaluation facilitation (UNITED NATIONS, 2007). Indicators are concrete tools which support the public politics planning and evaluation, strengthening decisions, as also citizen participation, for propelling countries towards the sustainable development (QUIROGA, 2001).

There are three generations of indicators models (QUIROGA, 2001). The first is composed by the classic indicators (from 1980) which do not evaluate the interrelationships between the components of the system, for example: air quality, water contamination, deforestation, desertification, among others. The second generation (from 1990) starts constructing matrices of indicators based on sustainability dimensions (social, environmental, economic and institutional), without establishing, however, interrelationships, having as main piece the “Blue Book”. The third generation is composed by models, created mainly from 1996 (Blue Book), which aim an ecosystem approach, that is, based on synergistic and cross-cutting linkages between the attributes or dimensions of sustainability, understanding that all factors are part of the same system in different scopes (global, national, regional and local).

Some researchers propose models of indicators under a behavioral focus which advise communities to adopt new practices that may increase the sustainability of the system where they live in (FREEBAIRN & KING, 2003). In this case, communities receive feedback to optimize the management of the exploitation of natural resources.

METHODOLOGY

Conceptual Structure for Indicators Construction

The model of evaluation proposed by this study is based on the methodological process named MESMIS (*Marco para la Evaluación de Sistemas de Manejo de Recursos Naturales incorporando Indicadores de Sustentabilidade*) which previews six steps accomplishment (LÓPEZ-RIDAURA et al., 2002). The steps of this methodology are clearly divided into three stages: (a) previous diagnoses taken by governmental or private institutions, for describing system strengths and weaknesses; (b) determination of indicators for statistical data collection and treatment; (c) proposition and execution of social interventions by the public power or related entities.

Sustainability Definition at Community Level

Sustainable communities are those who participatively discuss strategies based on local reality which interrelate the several dimensions (social, environmental, economic, political, cultural, and ethical) and attributes (productivity, resilience, reliability, stability, self-management, equity and adaptability), constructing actions which enhance life quality of that living place and of the planet as a whole. At community level, a system of nature conservation is sustainable if conserves the natural resources provided by the ecosystem towards the guarantee of life quality for related communities (VAN CAUWENBERGH et al., 2007). Landais (1998) argues that community must be characterized as productive, meaning that natural resources must be used and preserved through their good practices for their own use along decades.

Establishment of Evaluation Targets and Principles

The current study aimed (a) to carry documentary survey for determining critical points (strengths and weaknesses) related to the community of artisanal fishermen of Estiva Village, in the surroundings of the National Forest Ibura; (b) to determine the nominee indicators and to choose the potential indicators, adapting the MESMIS to the local reality for measuring the sustainability levels; (c) to classify the potential indicators chosen within components or attributes of sustainability (productivity; stability, resilience and reliability; adaptability; equity; self-management) and to measure them throughout field survey; (d) to apply the analysis model of sustainability built and demonstrate its importance through the radar chart and a relative index of sustainability, through descriptive statistics.

Identification, Selection and Measurement of Indicators

It was possible to identify variable nominee indicators, through documentary analysis of the strengths and weaknesses related to the National Forest Ibura, which were filtered through some criteria (simple, measurable, affordable, relevant and timely) and verified through MESMIS critical criteria: (a) easy to be implemented; (b) promptly understandable; (c) sensitive to variations; (d) reproducible; (e) adapted to objectives and relevant for user (GIRARDIN et al., 1999; GOMEZ et al., 1996; MEUL et al., 2008). Nominee indicators (strengths and weaknesses) are all noticed elements which are interesting for sustainability (Table 01), while the potential indicators are elements which effectively can be measured and precisely analyzed (BÉLANGER et al., 2012). Thus, the model composed by the potential indicators (Table 02) is the applicant tool for sustainability analysis and the radar graphic construction.

Many evaluation tools include interviewing communities to identify and select results from indicators (MEUL et al, 2008; REY-VALETTE et al., 2008; VAN CALKER et al., 2005). The research questionnaire was projected for the local scale and yet to feed the data required for the nominee indicators analysis (Table 01). Interviews with familiar groups were carried out by questionnaires application, giving priority to each family group leader. It was not necessary the sample calculation during the data collection from the family groups, then opting for a census survey. The data were collected from around 100 families who reside in the surroundings of the National Forest Ibura.

Table 01: List of candidate indicators, related to the strengths and weaknesses and respective attributes of system.

ATTRIBUTE	STRENGTHS AND WEAKNESSES	VARIABLES
Productivity	• Proximity to Cotinguiba River; • Access by state and federal highway facilitated.	• Variety of species caught (types); • Selling price of species caught ($ per Kg); • Technology employed in fishing (types); • Annual production in the region (Kg per year); • Family production (Kg per family); • Production per individual (Kg per person).
Stability, Resilience and Reliability	• Loss of cultural diversity; • Lack of qualified health and education public services; • High migration to urban centres.	• Residents (Qty); • Residences (Qty); • Age group of the population (age); • Artisanal fishermen (Qty); • Family groups (Qty); • Family groups of fishermen (Qty); • Composition of family income (%, types of income).
Adaptability	• Potential for ecotourism in the forest and river; • Culinary skills of women; • Local natural resource degradation; • High environmental vulnerability due to access; * Industrial pollution.	• Income alternatives if fishing is compromised (types); • Species used for extraction of vegetable (Qty); • Maximum range of artisanal fisheries (Km); • Collecting fruits and seeds in natural protected areas (types).
Equity	• Low income; • Low profitability of production systems; • Lack of employment on the spot; • Jobs generated by cement factory; • Jobs generated by shrimp farming.	• Total income per family broken down by source (R $ per family); • Per capita income (total income/Population); • Fishing's contribution to family income (R $ per family); • Grants and allowances contribution to family income (R $ per family); • Contribution of manufacturing jobs to the family income (R $ per family); • Fish and shrimp farming contribution to the family income (R $ per family); • Urban/rural services contribution to the family income (R $ per family); • Contribution from other sources to the family income (R $ per family).
Self-management	• ICMBio investments in the management of the FLONA Ibura; • Low cooperative and organizational capacity; • Lack of management plan of the FLONA Ibura; • Preponderance of disqualified labour.	• Cooperative or associative organisations (Qty); • Binding of the population to the associations and cooperatives (Qty); • Trainings and training bodies (Qty, Type); • Skilled fishermen (Qty); • Technical visits carried out in the area (Qty per family).

The indicators were divided into components (productivity, resilience, reliability, stability, self-management, equity, and adaptability) as recommended by the sources of reference literature (LÉLÉ, 1993; CONWAY, 1994; GIDSA, 1996; GALLOPIN, 2002; MASERA et al., 2008).

Besides measuring the variables specified in the Table 01, general information about familiar kennels were collected, as following number of family members, gender, age, marital status, number of children, religion, level of education, occupation, and wage level. The following nominee indicators - variety of fish species collected; variety of shellfish species collected; variety of equipment/technology applied were analyzed to evaluate the productivity of the artisanal fishery. The following nominee indicators number of fishermen family groups; age group of the population; income per fishermen family group; variety of sources of household income were assessed to evaluate the resilience, reliability, and stability of the community. The following nominee indicators binding of fishermen to associations and cooperatives; record of training for groups of fishermen; registration of technical visits to groups of fishermen were analyzed to evaluate the community self-management. The following candidate indicators - fishing contribution to family income; fish and shrimp farming contribution to family income were assessed to evaluate equity of fishermen´s income. The following nominee indicators were analyzed: maximum range of artisanal fisheries; variety of species and derivatives on the vegetable extraction to assess the adaptability of the fishery community in the generation of income.

Statistical Analysis

Some candidate indicators did not present significant results, being discharged, for compounding the resulting model of potential indicators, after data collection. The descriptive statistics analyzed (N = 100) through census the minimum (MIN), medium (MED), desirable (P75), and maximum (MAX) parameters. The resulting model is composed by 14 sustainability indicators, distributed within the attributes: (a) productivity; (b) stability, resilience and reliability; (c) adaptability; (d) equity; (e) self-management.

The reference parameters of the system are defined as an optimum level (MAX) and an unwanted level of sustainability (MITCHELL et al., 1995). The average value (MED) represents the diagnosed situation of the potential indicator, being considered the average of the averages of the sustainability relative index indicators (SRI). The 75 percentile values (P75) represent references of the own system with advance beyond the average, becoming a reference for improving the RIS. The percentile has already been used in other contexts to evaluate the results from a monitoring tool for environmental systems (VASSEUR et al., 2010).

The indicators have specific and different units of measurement that is why converting in percentages was necessary to homogenize the results to be applied in the production of graphics and in the calculation of the SRI. So, it was possible to have a score that simplifies the comparison of different systems, and the same system in the temporal scale, improving the presentation of the results in charts of Radar type (Figure 01).

The research was examined and approved by the Embodied Opinion of Research Project issued by the Ethics Committee on Research of the Tiradentes University (Brazil) through Protocol 110712, in July 25th, 2012.

RESULTS AND ARGUMENTS

Choosing the potential indicators (Table 02) was based on the perceptions obtained during the data collection, giving priority to the nominee indicators which could be easily calculated and understood by the related public. Although only collecting the data is not enough to permit model validation, it is possible to perceive that the potential indicators are easily measured and calculated. In this point, there is a risk of losing information, by discharging some nominee indicators, but as Goodland (1995), affirms it is better to be nearly right than precisely wrong.

Results from the Measurement of the Last Indicators

Table 02: Results from the evaluation of sustainability of artisanal fishery in the surroundings of the National Forest Ibura, in 2012.

Component	Indicator (Measure Unit)	MIN	MED	P75	MAX	MIN %	MED %	P75 %	MAX %
Productivity	Variety of fish species collected (QTY)	0	1,9	3	9	0%	21%	33%	100%
	Variety of shellfish collected (QTY)	0	2,9	4	9	0%	32%	44%	100%
	Variety of equipment/technology employed (QTY)	1	1,9	2	4	25%	48%	50%	100%
Stability, Resilience and Reliability	Quantity of familiar groups of fishermen (QTY)	0	36	75	100	0%	36%	75%	100%
	Age of population (Years)	2	30	42	80	3%	38%	53%	100%
	Income per familiar group of fishermen (R$)	70	834,69	858	2488	3%	34%	34%	100%
	Variety of sources of familiar income (QTY)	1	2	2	3	33%	67%	67%	100%
Adaptability	Maximum range of artisanal fisheries (Km)	0	1,7	2,3	3	0%	57%	77%	100%
	Variety of species and derivatives on the vegetable extraction (QTY)	0	0,3	0,3	1	0%	30%	30%	100%
Equity	Fishing's contribution to family income (%)	0	4	0	100	0%	4%	0%	100%
	Fish and shrimp farming contribution to the family income (%)	0	0,3	0	12	0%	3%	0%	100%
Self-management	Binding of fishermen to associations and cooperatives (QTY)	0	0	0	36	0%	0%	0%	100%
	Record of training for groups of fishermen (QTY)	0	0	0	36	0%	0%	0%	100%
	Registration of technical visits to groups of fishermen (QTY)	0	0	0	36	0%	0%	0%	100%
							Sustainability Relative Index: $\overline{MED\%}$ = 26%		**$\overline{P75\%}$ = 33%**

Subtitle: MIN - Minimum; MED - Medium; P75 - Percentile 75; MAX - Maximum.

The results for each indicator are presented in the Table 02 based on 36% of familiar groups, that is, the self-named artisanal fishermen or extractors. If an indicator has a maximum or minimum value in all familiar groups, there is no reason to reject it, but, it indicates that the family has already been well succeeded in this parameter, or needs to improve it. A model of indicators at community level can show the consequences of management decisions more efficiently if evaluated repetitively along the years (HALBERG, 1999). In this study, only one punctual evaluation in temporal scale was carried out; this disadvantage can be softened by involving the community in self-evaluations to be stimulated by the local conservation unit management and government. The planning of sustainable strategies must start in the community, and not only from public managers or private enterprises actions. The best way to interpreter the results is through the comparison with other similar components (TZILIVAKIS & LEWIS, 2004).

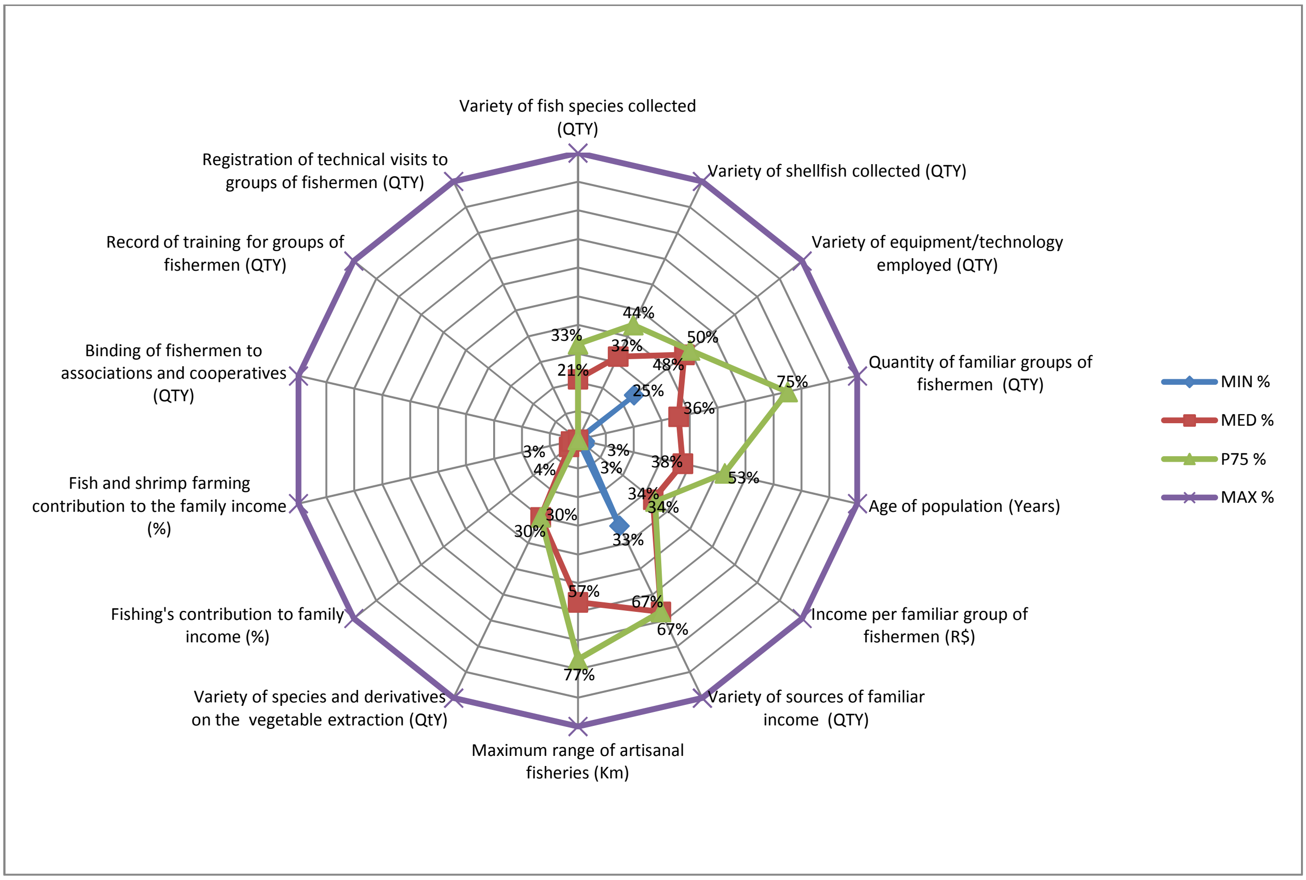

Figure 01: Radar graphic resulted from the evaluation of the sustainability of the artisanal fishery in the surroundings of the National Forest Ibura, Brazil, in 2012.

Analyzing the results obtained from the combination of Productivity indicators, it can be observed that the fishing coverage area causes amplitude of 09 fish species, added to 09 shellfish species, yet known and collected by this community. However, the data reveal that in average each familiar group collects approximately 02 fish species and 03 shellfish species, what represent only 22% and 33% of the potential of the regional species diversity. This productivity deficiency is related with the lack of capacity and diversity on using fishing equipment and technics, since the major part of the fishermen uses only the manual fishing or trawl fishing.

Observing ‘Stability, Resilience and Reliability’ and Equity indicators, it is noticed that fishing and agriculture are not the local economic base, even being natural and geographically opportune, being the livelihood based on informal services (71,4%), followed by job vacancies offered by the surrounding industries (17.8%), by financial support grants from the federal Government (9.0%), and ultimately the income generated by fishing and fish farming, which combined represent only 1.7% of the total monthly income of 36 fishermen families. The average age in the fishermen families is 30 years, but only 25% of this group is in the range between 42 (P75) and 80 (MAX), which shows a local exodus in searching for other sources of income. On average, each family group has 02 (two) sources of income. Despite of monthly family income of $

2,488 .00 (MAX) registered, and a majority getting between R$ 834,69 (MED) and R$ 858,00 (P75) monthly, the situation of some families is worrying, closer to the threshold of R$ 70,00 (MIN) identified.

The Adaptability indicators show that the community does not have technical and instrumental capacity to extend the collection area farther than 3,0 Km., that is, fishing is made only in the surroundings of the National Forest Ibura. On average, these extractors displace themselves from their residences to one average distance of 1,7 Km for collecting material. Extraction is predominantly animal, because the only one source of vegetable collection is wood.

Despite the efforts in data collection, the Self-management indicators do not present coherent registrations, what means that population is totally unconcerned about any knowledge, technic or instrument of economic and natural resources management linked to extracting or fishing activity. There are not communitarian organizations, like local associations or cooperatives, and neither any fisherman family nor fisherman has received any capacitation or technical visit from the surroundings industries, managers of the National Forest Ibura, NGOs, or even the local government.

CONCLUSIONS

The results from this study show that it is possible to take mathematical analyses related to the sustainability of the natural resources systems, having in the MESMIS and in its adaptation one powerful tool for obtaining the last calculation of the Sustainability Relative Index (SRI). It was determined that the SRI ($\overline{MED\%}$) of the fishery community of the surroundings of the National Forest Ibura is of 26%.

The calculated levels of sustainability can be improved significantly through interventions in components (attributes) of the Table 02, especially in Self-management component that is reflecting negatively on all the others. A reference for improving the sustainability of the system is the average of results 75 percentile ($\overline{P75\%}$) that was 33%. This improvement in the quality of life of this community can be stimulated through the creation of associations and cooperatives, carrying out training and technical visits, everything related to improvement of technical conditions, and economic instruments of local fishing and aquaculture.

A better understanding of the living conditions of this community of artisanal fishermen may be obtained by repeating this indicators analysis along other timelines, and yet from comparing these data with local or other regional existing similar communities. New measurements may help to add new indicators to the proposed model, and also for the development of methodology for self-statistical analysis. Future researches may also help by attributing different scores to the indicators used.

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