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Measurement and Comparison of Different Dimensions of Sustainable Coastal Fishing Management in Beach Seine Cooperatives in Guilan

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ABSTRACT

Sustainable coastal fishing management includes different components and factors. One of the practical initiatives to achieve sustainability is to evaluate or measure different criteria of sustainability and measuring sustainability of each system needs its own indicators. This study aimed to investigate different criteria of sustainable coastal fishing management in Beach Seine Cooperatives (BSC) in Guilan Province of Iran and to analyze different aspects of sustainable coastal fishing management in the cooperatives. The statistical populations of the research were 58 active BSC's of Guilan Province, 36 of which were determined through formula of Cochran and were selected randomly. Sampling was done from September 2011 to April 2012.The method used in this research was descriptive-survey research and data was gathered through questionnaires. Reliability of the questionnaire was confirmed with Cronbach's Alpha that was calculated for each of the seven criteria of the questionnaire (Cronbach's α coefficients ranging from 0.78 to 0.93). The construct validity was analyzed with a factorial analysis of the main components whose applicability was verified by means of Bartlett's test of sphericity and the KMO test (acceptable with values above 0.6). Technique used in this study was Multi-Criteria Analysis (MCA), a general approach that can analyze complex problems involving multiple criteria used in sophisticated systems such as fishing. MCA is a decision-making tool to analyze and evaluate multiple indicators under a participatory group decision-making environment. Seven variable criteria of sustainability indicators including ecological, economic, social, institutional, coastal management, restocking the reserves, and resource conservation indicators were investigated. According to the results, social sustainability in BSC cooperatives had the best situation among different criteria of sustainable coastal fishing management, while the economic coastal management and resource conservation criteria had unfavorable status of sustainability.

Keywords: Multi-criteria analysis techniques, Social sustainability, Sustainability indicators.

INTRODUCTION

Fishery is known to be an important activity throughout the world that produces more than 100 million tons of fish and fishery products and contributes to human welfare by providing a livelihood to about 200 million people and protein supply for a billion people. More people than ever before rely on fisheries for food and as a source of income, but harmful practices and poor management threaten the sector's sustainability (FAO, 2014).

With declining stocks as well as several evidences related to fisheries, sustainability issue has become very important and has been discussed as the central topic in fishery sciences and industries. These conditions are mainly encouraged by the unfortunate reality that many fisheries are in a state of crisis and

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some of them demanding urgent attention (Adrianto *et al.*, 2005; Pauly, *et al.*, 2002; Garcia, *et al.*, 2000; Cochrane, 2000; Charles, 2001). Historically, fisheries have tended to be non-sustainable (Pauly *et al*., 2002). Lack of good governance, inappropriate incentives, high demand for limited resources, poverty and lack of alternatives, complexity and lack of knowledge as well as the interactions of the fisheries sector with other sectors and the environment have been identified as primary causes of non-sustainability (Greboval, 2002; 2004; Filipa Ribeiro Baeta, 2009).

Sustainable coastal fishing management includes different components and factors. One of the practical initiatives to achieve sustainability is to evaluate or measure different criteria of sustainability, and measuring sustainability of each system needs its own indicators. Indicators are measures used to quantify or qualitatively describe phenomena that are not easily measured directly, but which society considers valuable to monitor over time. People have used indicators for many decades to communicate information about complex systems or phenomena in a way that is relatively simple to understand. Indicators are useful for sharing the results of technical analysis or for monitoring characteristics of systems, such as fishery systems, to inform public decisions. In particular, indicators have become very useful in monitoring 'sustainable development' a complex and often ambiguous concept that cannot be measured directly (Boyd and Charles, 2006). Indicators are also useful for comparing different criteria of sustainability of each system, for example fisheries; they also allow comparisons across countries (Le Gallic, 2002).

Indeed, sustainable management is a multi-criteria concept that integrates economic, social, institutional, ecological, coastal management, restocking the reserves and resource conservation criteria.

The methods and fishing gear used to catch fish are a determining factor of sustainability as they can impact marine life and habitats. Over the past 50 years, fishing technology has advanced greatly, increasing the capacity for boats to locate and catch fish. There have also been advances to reduce the environmental impact of fishing, yet there is room for further improvement and research and development is ongoing. This study employed a participatory approach to measure fishery management sustainability by using a multi-criteria analysis (Adrianto *et al.,* 2005) and aimed to assess and compare different criteria of sustainable coastal fishing management in Beach Seine Cooperatives (BSC) in Guilan Province of Iran.

MATERIALS AND METHODS

Guilan Province is located in the northeastern part of Iran with the Caspian Sea to its north. To assess different criteria of sustainable coastal fishing management in this province, 36 major BSC's (out of 58) were selected trough Cochran's formula and a formal methodology called Multi-Criteria Analysis (MCA) was used. According to Mendoza and Prabhu, 2003; MCA is a general approach that can be used to analyze complex problems involving multiple criteria, and also has advantages when applied in a complex and sophisticated system like fisheries (Adrianto *et al.*, 2005). At least there are three advantages of this method for fishery sustainability management assessment. First, it can deal with mixed sets of data, quantitative or qualitative, including stakeholders' opinions. Fisheries, as a system, are well known to be complex and stochastic so that incomplete information and understandings may exist. In this case, qualitative information from stakeholders, including experts groups, and experiential knowledge, have distinct advantages for assessing sustainability indicators of fisheries system (Mendoza *et al.*, 2003; Adrianto *et al.*, 2005). Secondly, the MCA approach also can be conveniently structured in order to enable a collaborative

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planning and decision-making environment. This environment provides an opportunity to develop such an accommodation for the involvement and participation of stakeholders in the sustainability assessment process. Finally, the MCA methodology is also still simple, intuitive, and transparent while it has strong technical and theoretical support in its procedure (Adrianto *et al.*, 2005; Prasetiamartati *et al.,* 2006). Following Mendoza and Prabhu (2003), MCA is used as a decision-making tool to analyze and evaluate sustainability under a participatory group decision-making environment. This method can be used for generating criteria and indicators for sustainable management, estimating their relative importance, estimating the performance of each indicator relative to its desired condition.

The analysis using MCA approach was done in two parts. The first part was to generate a set of management indicators for sustainable coastal fishing (Table 1). The methods used in this part of analysis were varied, ranging from expert driven and top-down to bottom up, and locally defined (Adrianto *et al.,* 2005). This study followed Prasetiamartati, *et al.* (2006) and used a mixed-method approach, which combined expert-driven sustainable coastal fishing management indicators (Pitcher and Preikshot, 2001) and, then, these indicators were confirmed by the local stakeholders in order to generate a "locally accepted "fishery sustainability indicators in Guilan Province (using a 5-point scale, namely: 1: disagree ; 3: Moderately agree; 5: strongly agree, and 2 and 4: Intermediate values).

In this study, we used a set of sustainability indicators which were composed of seven variable criteria of sustainability indicators, namely, ecological (9 indicators), economic (5 indicators), Social (12 indicators), institutional (5 indicators), coastal management (7 indicators), restocking the reserves (2 indicators), and resource conservation (12 indicators) (Table 1). These indicators were modified from fisheries sustainability indicators formulated by Pitcher and Preikshot (2001), Charles (2001), Adrianto *et al.* (2005), and Prasetiamartati *et al.* (2006).

The second part of analysis evaluated the sustainability indicators in terms of their importance by ranking each indicators using a 5-point scale, namely: 1: Less important, 3: Moderately important, 5: Extremely important, and 2 and 4: Intermediate values. A different scale was proposed by Mendoza and Prabhu (2003) using a 9-point scale, and Adrianto *et al.* (2005) using a 7-point scale. However, for reason of simplicity during stakeholder meeting, this study used 5-point scale. Based on these rankings, relative weight of an indicator was then estimated using a formula as follows (Mendoza and Prabhu, 2003; Adrianto, *et al* 2005; Prasetiamartati *et al.,* 2006):

$$w_j = \frac{a_j}{\sum a_j} \qquad (1)$$

Where, a_j is the average weight of indicator *j* and w_j is the relative weight of indicator *j* [Equation (1)]. The next analysis examined each indicator by judging their current condition relative to their perceived target or desired condition (Mendoza and Prabhu, 2004, Adrianto *et al.,* 2005). The desired condition was to reflect or represent a sustainable status of coastal fishing management indicators. In this respect, an MCA approach of 5-point scale was applied, following Adrianto *et al.*(2005), with values 0: Unsustainable, 1: Extremely weak performance, 2: Poor performance\unfavorable, 3: Acceptable, 4: Very favorable performance, 5: Sustainable. Then, the sustainability indicator score (SIC) was calculated using the following formula:

$$\text{SIC} = \sum S_j W_j \qquad (2)$$

Where, *SIC* is sustainability index of criteria *i*: Sustainable fishery (ecological, economy, social and institutional), coastal area management (fishery and non-fishery activities), recruitment management, resource conservation management; S_j is the score of indicator *j*, and W_j is the relative

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Table 1. List of indicators for sustainable coastal fishery management.

Criteria	Indicators	Average weight	Relative weight	Average score	SIC
Ecological	Number of fishing fleet	3.78	0.150	3.58	0.537
	Diversity	3.21	0.128	3.56	0.455
	Premature fishing	2.87	0.115	3.5	0.402
	Number of migratory species	3.84	0.154	2.58	0.397
	Loss of fishing area	2.84	0.113	3.34	0.377
	Discard by catch	3.36	0.135	2.58	0.348
	Size of fishing net	2.06	0.087	3.37	0.293
	Biomass	1.66	0.066	3.39	0.223
	Size of fish caught	1.45	0.052	2.75	0.143
	Total sustainability of ecological criteria				3.175
Economic	Market price of fish	3.12	0.484	2.89	1.398
	Fisheries contribution	1.75	0.272	2.67	0.726
	Income from fishing	0.85	0.132	3.34	0.440
	Volume of catch	0.54	0.084	2.57	0.215
	Share of catches and fishing per person	0.18	0.028	3.75	0.105
	Total sustainability of Economic criteria				2.88
Social	Environmental knowledge	3.27	0.144	3.83	0.551
	Conflict status within the cooperatives	3.75	0.165	3.25	0.536
	Conflict status between the cooperatives	2.78	0.125	3.11	0.388
	Conflict status with other sectors	2.66	0.116	2.75	0.319
	Fishers participation on fisheries' law enforcement	2.96	0.130	3.83	0.497
	Fishers influence on fisheries' laws and regulations	1.69	0.075	3.39	0.254
	Full insurance of fishermen staff	1.27	0.055	3.89	0.213
	Full insurance of cooperatives members	0.90	0.039	3.96	0.154
	Full insurance of employed fishermen	1.33	0.059	2.00	0.118
	Education level	1.27	0.056	2.66	0.148
	Fishing community growth	0.72	0.031	3.88	0.120
	Kin participation	0.12	0.005	0.83	0.004
	Total sustainability of Social criteria				3.302
Institutional	Fishing tools policy	3.03	0.258	3.93	1.013
	Consulting with fisherman for policy making	3.02	0.256	2.88	0.737
	Fishing place policy	2.72	0.232	2.58	0.598
	Formal and informal fishing regulations with paying attention to stakeholder's interests	1.81	0.154	2.98	0.458
	Fishing Time policy	1.18	0.1	3.93	0.393
	Total sustainability of institutional criteria				3.19
Coastal management	Cooperative's role in disposal of Fishing waste	3.54	0.253	2.86	0.723
	Cooperative's role in eliminating direct effects of fishing gear on ecosystems	3.48	0.249	2.46	0.612
	Tourism attraction in fishing time	1.83	0.131	3.83	0.501
	Tourism attraction in other time	1.72	0.123	3.72	0.457
	Cooperative's participation in defining fishing area	1.69	0.121	2.08	0.251
	The non-fisheries activities within the cooperative's area	0.84	0.061	2.33	0.142
	Tourism attraction in Non-fishing season	0.87	0.062	2.25	0.139
	Total sustainability of coastal management criteria				2.825

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Continued of Table 1.

Criteria	Indicators	Average weight	Relative weight	Average score	SIC
Restocking the reserves	Cooperative's role in resource rehabilitation program	2.87	0.591	3.06	1.808
	Cooperative's participation in the formulation of management plans of restocking the reserves	1.93	0.409	2.75	1.124
	Total sustainability of restocking the reserves criteria				3.048
Resource conservation	Cooperative's monitoring on prevention of Juveniles and productive fish caught	3.06	0.125	2.75	0.343
	Selection of fishing equipment in accordance with the standards	3.66	0.149	1.75	0.26
	Cooperative's monitoring of illegal fishing in the sea and dealing with them	2.36	0.097	2.41	0.232
	Reduction of fishing non-target species	3.03	0.123	1.88	0.231
	Management plans to restrict fishing of certain species that are at risk	2.48	0.102	2.25	0.229
	Impact of fishing on biodiversity	1.66	0.068	2.82	0.192
	Cooperative's monitoring of illegal fishing in the rivers and dealing with them	1.81	0.074	2.33	0.172
	Limiting the amount of fish caught in juveniles and productive fish	3.00	0.122	1.32	0.161
	Cooperative's participation rate at determining the beginning and end of the fishing time	0.93	0.037	3.87	0.143
	Existence of fishing prohibited or protected areas	1.51	0.062	2	0.124
	Effectiveness of activities to stop illegal fishing	0.81	0.032	3.53	0.113
	Reduction rate in illegal fishing in the area	0.24	0.009	2.08	0.018
	Total sustainability of resource conservation criteria				2.219

weight of indicator *j* [Equation (2)].

The SIC range was from 0 to 5 with values 0: Unsustainable, 1: Extremely weak performance, 2: Poor performance\ unfavorable, 3: Acceptable, 4: Very favorable performance, and 5: Sustainable.

RESULTS

As mentioned in the previous section, the first analysis for sustainability indicators was to generate a set of indicators in terms of their importance judged by a group of stakeholders and experts. The next part of analysis was to estimate the "sustainable state" elaborated from the perceived targets or conditions judged by the stakeholders and experts. This analysis was started by judgments of the stakeholders and experts to score the perceived targets of each indicator followed by the calculation of Sustainability Index of Criteria (SIC). The results are presented in Table 1 and Figure 1.

Table 1 shows indicators of sustainable coastal fishing management for different criteria (ecological, economic, social, institutional, coastal management, restocking the reserves and resource conservation).

According to SIC, among ecological indices of sustainability, the number of fishing fleet had the best situation, while size of fish caught had the lowest position. Thus, fishermen believed that size of fish caught is decreasing in the past years and this reveals the crisis of excessive harvest of the reserves and resources in the Caspian Sea. Note that ecological sustainability score was 3.175 (according to the SIC score of above 3, this criteria had acceptable situation).

As to the economic criteria, market price of fish had the most important role in

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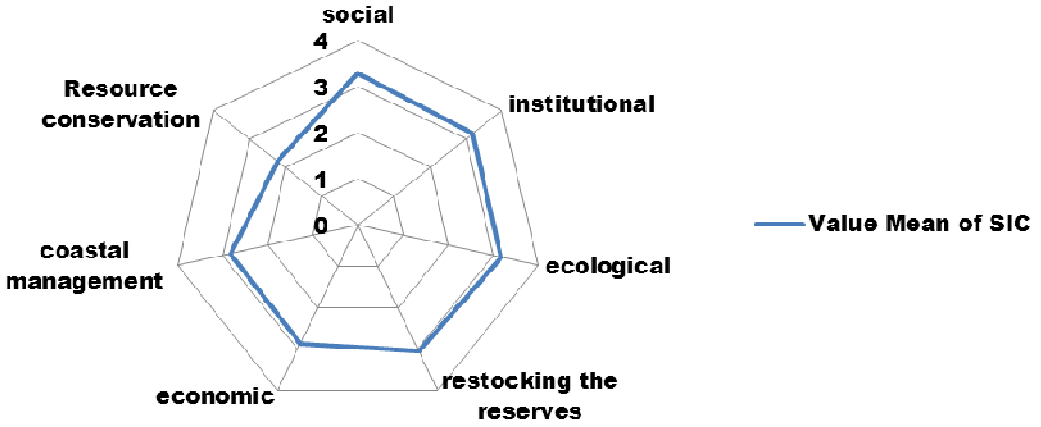

Figure 1. Radar diagram of sustainable coastal fishing management criteria.

economic sustainability of BSC, such that with increasing price, cooperatives with a certain amount of fish caught provided more money, but with reduction in the price, fisherman were forced toward excessive fishing to meet their needs, which added pressure on the reserves. In addition to economic instability, it has ecological impact. Among economic indices, share of catches and fishing per person had the lowest score among others, due to the large number of fishermen in comparison with catch rates. Hence, fishermen had a lot of problems for their livelihood. As shown in Table 1, economic SIC was 2.88, which is below 3 and indicates that economic criteria had unfavorable condition in respect to sustainability.

Among social indices of sustainability, environmental knowledge had the most important role in fishing cooperatives while kin participation had the lowest score. This is due to the lack of family involvement in the after-fishing process in the mentioned cooperatives that has a major impact on social sustainability. Also, the social SIC was 3.302, reflecting acceptable situation in terms of sustainability.

In institutional sustainability indices, fishing tools policy had the most significant role and fishing time policy had the least score. Fishermen believed that the time policy-making process was top-down and inappropriate, and they faced numerous problems, which should be considered in policy making. Institutional sustainability score was calculated at 3.19, which was acceptable in terms of sustainability.

According to SIC calculation, cooperatives' role in disposal of fishing waste had the most important grade in sustainable coastal fishery management while tourism attraction in non-fishing season had the least score. This can be one of the reasons for the low income of fishermen working in BSC's in Guilan Province compared with Mazandaran Province, where in non-fishing season Jet Ski and parachuting in the sea is available but in Guilan Province these activities are not allowed. The total score SIC for coastal management was calculated at 2.825,

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reflecting that the coastal management has poor performance in terms of sustainability.

Among restocking the reserves indices, cooperative's role in resource rehabilitation programs had the most important role and cooperative's participation in the formulation of management plans of restocking the reserves had the least role. This indicates lack of possibility of participation in the formulation of management plans and policy making in the context of restocking the reserves. The total score SIC for restocking the reserves criteria was calculated at 3.048, which shows that the restocking the reserves criteria has acceptable situation in terms of sustainability.

As shown in Table 1, cooperative's monitoring on prevention of juveniles and productive fish caught has the highest score among resource conservation indices and the biggest problem in the area of sustainable coastal fishing conservation was illegal fishing. Thus, the fishermen believed that illegal fishing was not reduced and inhibitory activities were not effective. The total score of resource conservation criteria was 2.219, reflecting unfavorable condition of sustainability.

The results are presented in Table 1. We can see that sustainability index for the social indicators was the highest among other sustainable coastal fishing management variables (SIC=3.302), followed by the institutional (SIC= 3.19), ecological (SIC= 3.175), restocking the reserves (SIC= 3.048), economic (SIC= 2.88), coastal management (SIC= 2.825), and resource conservation indicators (SIC= 2.219). Graphically, the sustainability index of criteria for sustainable coastal fishing management in Guilan can be seen in Figure 1.

The results of SIC mean that based on their perceived value of condition for each indicator, the stakeholders and experts judged that social indicator variable had the relatively best condition, while resource conservation indicator variable had the worst.

According to Figure 2, comparing sustainability condition of different criteria of coastal fishing management with the SIC scores above the value of 3 (acceptable) shows that economic, coastal management, and resource conservation criteria have unfavorable condition of sustainability.

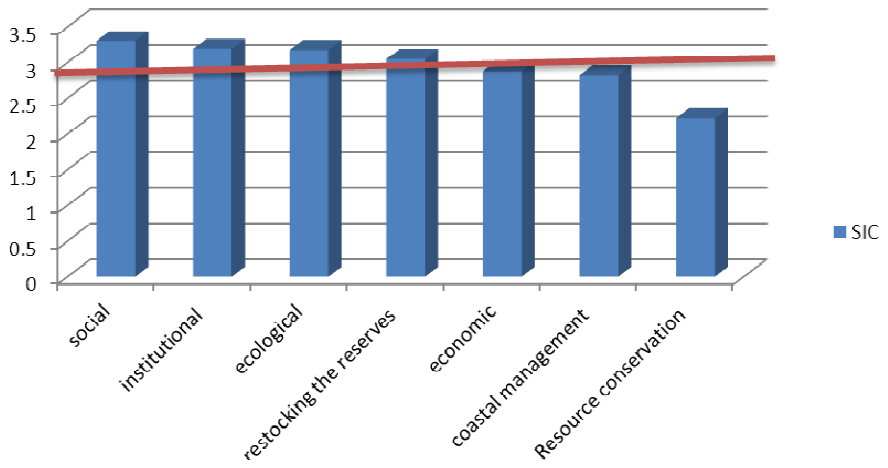

Figure 2. Sustainability status of different criteria of coastal fishing management**.**

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DISCUSSION

This paper analyzed different criteria of sustainable coastal fishing management in Beach Seine Cooperatives in Guilan. MCA approach was used to evaluate sustainability of each criterion under a participatory assessment methodology including the stakeholder analysis. In addition, indicators were set up using a modified fishery indicators list by FAO (1999), Charles (2001), and Adrianto *et al.* (2005), then, evaluated by estimating their degree of importance by experts and stakeholders. Subsequent to estimating their relative weight, indicators were also evaluated by giving them scores that reflected the condition of each indicator.

The findings of this study is similar to the application of Rapfish (Rapid Appraisal for Fisheries) in assessing twelve fishing tools used in the coastal area of Jakarta (Fauzi and Anna, 2005) and destructive fishery and fishery sustainability assessment using a multi-criteria participatory approach: a case study of small islands in South Sulawesi (Prasetiamartati *et al.*, 2006). However, our results are not similar to findings of Adrianto *et al.* (2005) in Japan, where ecological sustainability indicators had the highest SIC score and institutional sustainability had the lowest SIC score. That is because of the good ecological conditions of the Japan Sea.

CONCLUSIONS

According to our findings, social sustainability in Beach Seine cooperatives had the best situation among different criteria of sustainable coastal fishing management, while economic, coastal management, and resource conservation criteria had unfavorable condition of sustainability. Also, in economic criteria, the most important problem was the high number of fishermen compared with catch value. In this case, adjusted number of fishermen employed in the cooperative and determining the optimum size of employment per cooperative, is the most important issue. In coastal management criteria, integrated coastal management in collaboration with other organizations and sectors through interactive seminars and approval procedures to consider the interests of all stakeholders is required. According to our results, the most important problem in resource conservation criteria was failure to reduce illegal fishing in the fishing cooperatives area. That can be solved through creating a special and appropriate utilization system by giving sense of ownership to the Beach Seine cooperatives to protect their fishing area against illegal fishing. Also, it should be mentioned that all the above solutions must be founded on, and run according to, the basic principles of sustainable development.

Overall, Beach Seine fishing cooperatives deserve more consideration than they have received. As we have shown, properly designed cooperatives in conjunction with policies like appropriate utilization and participatory planning can do better than other alternatives that are being used.

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اندازه گیری و مقایسه ابعاد مختلف مدیریت صید ساحلی پایدار در تعاونیهای پره استان گیلان

ش. چوبچیان، خ. کلانتری، ع. اسدی، و س. ا. تقوی مطلق

چکیده

مدیریت صید ساحلی پایدار شامل مولفه‌ها و عوامل متعدد است. یکی از طرحهای عملی برای رسیدن به پایداری، ارزیابی و اندازه گیری معیارهای متفاوت پایداری است و اندازه گیری پایداری هر نظام

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نیازمند شاخصهای ویژه خود است. این مقاله با هدف بررسی معیارهای مختلف مدیریت صید ساحلی پایداری در تعاونی‌های پره استان گیلان و تحلیل ابعاد مختلف مدیریت صید ساحلی پایدار در این تعاونیها تدوین شده است. جامعه آماری تحقیق حاضر ۵۸ تعاونی پره فعال در استان گیلان بودند که ۳۶ تعاونی از طریق فرمول کوکران تعیین و به روش نمونه گیری تصادفی انتخاب شدند. نمونه گیری از مهر۱۳۹۰ تا آخر فروردین ۱۳۹۱ انجام گرفت. روش مورد استفاده در این پژوهش توصیفی-پیمایشی بوده و داده ها از طریق پرسشنامه جمع آوری شد. اعتبار پرسشنامه با محاسبه آلفای کرونباخ برای هر یک از هفت معیار پرسشنامه (ضریب آلفای کرونباخ در محدوده۰/۷۸ – ۰/۹۳ بود) تایید گردید. اعتبار سازه با تحلیل عاملی مولفه های اصلی که مقبولیتش با معنی داری آزمون کرویت بارتلت و آزمون KMO (بالای ۰/۶) مورد تایید قرار گرفت، انجام شد. تکنیک مورد استفاده در این مقاله، تکنیک آنالیز چند معیاری Multi criteria analysis (MCA) به عنوان یک رهیافت عمومی است که می‌تواند جهت تحلیل نظام‌های پیچیده مثل صید و صیادی مورد استفاده قرارگیرد. تکنیک آنالیز چند معیاری یک ابزار تصمیم گیری برای تجزیه و تحلیل و ارزیابی شاخصهای چندگانه در یک محیط تصمیم گیری مشارکتی است. هفت معیار شاخص‌های توسعه پایدار را تشکیل می‌دهند که عبارتند از: شاخصهای معیار اکولوژیکی، شاخصهای معیار اقتصادی، شاخصهای معیار اجتماعی، شاخصهای معیار نهادی، شاخصهای معیار مدیریت ساحل، شاخصهای معیار بازسازی ذخایر و شاخصهای معیار حفاظت منابع. نتایج به‌دست آمده نشان داد که پایداری اجتماعی در تعاونی های پره بهترین وضعیت را در میان معیارهای متفاوت مدیریت صید ساحلی پایدار دارا بوده، این درحالیست که معیارهای اقتصادی، مدیریت ساحل و حفاظت منابع وضعیت نامطلوبی از لحاظ پایداری دارا می‌باشند.

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