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RESEARCH PAPER

An Assessment of Al Batinah Fishery with Respect to Ecologically Sustainable Development Using Multi-Criteria Decision Analysis Approach

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تقييم مصايد الباطنة فيما يتعلق بالتنمية المستدامة بيئياً باستخدام نهج القرار متعدد المعايير

هدى السيابي[١،*] وحسين المسروري[٢]

Abstract. Globally, sustainable development is considered as a vital need to fisheries sector that integrated both human and environmental well-beings. This issue was recognised by the Omani government therefore, it started to promote the fishery management system by establishing new fisheries development plans and management policies to achieve the sustainable development goals. This study aimed at assessing the progress of Al Batinah fishery towards sustainable development using Ecologically Sustainable Development (ESD) framework and Multi-Criteria Decision Analysis approach (MCDA) from 2008 to 2017. A consultation review was conducted to identify all possible components (criteria) of the ESD framework. Progress of each component toward sustainability and sensitivity analysis were conducted to identify strengths and weaknesses of components. Attainment toward sustainability in Al Batinah fishery progressed a positive trend. Scores increased from 50 points (on 100 points scale) in year 2009 to 81 points in year 2016. Specifically, the progress toward sustainability in the human well-being was better. The scores increased from 55 points in year 2009 to 95 points in year 2016 indicating excellent progress. However, the progress toward sustainability in the environmental well-being was minimal. The scores increased from 42 points in year 2008 to only 67 points in the last three years 2015 to 2017 indicating a slow and a below average progress. The results indicated that the year 2016 had the best attainment toward sustainability and the management measures and/or practices adopted in 2016-favoured socio-economic development more than conserving the environment. Sensitivity analysis confirmed that year 2016 was the most preferred year and provided different strengths and weaknesses to improve both human and environmental well-beings and consequently improving the progress toward sustainability. The management authority is therefore advised to adapt conservative measures to promote and protect the environment. In the long-term, such preferences of human well-being over environment might threaten the whole fishery.

Keywords: Fisheries sustainable development, Sensitivity analysis, ESD framework, Al Batinah Fishery

الملخص: على الصعيد العالمي، تعتبر التنمية المستدامة حاجة حيوية لقطاع مصايد الأسماك الذي يدمج الرفاه البشري والبيئي. تم إدراك هذه القضية من قبل الحكومة العمانية، لذلك بدأت في تعزيز نظام إدارة مصايد الأسماك من خلال وضع خطط جديدة لتنمية مصايد الأسماك، وسياسات الإدارة لتحقيق أهداف التنمية المستدامة. هدفت هذه الدراسة إلى تقييم التقدم المحرز في مصايد الباطنة نحو التنمية المستدامة باستخدام إطار التنمية المستدامة بيئيًا(ESD) ونهج تحليل القرار متعدد المعايير (MCDA) من ٢٠٠٨ إلى ٢٠١٧. تم إجراء مراجعة استشارية لتحديد جميع المكونات (المعايير) الممكنة لإطار (ESD). تم إجراء تقييم التقدم نحو الاستدامة وتحليل الحساسية لكل مكون لتحديد نقاط القوة والضعف في المكونات. أظهر التقدم نحو الاستدامة في مصايد الباطنة اتجاها إيجابيا. زادت الدرجات من ٥٠ نقطة (على مقياس ١٠٠ نقطة) في عام ٢٠٠٩ إلى ٨١ نقطة في عام ٢٠١٦. على وجه التحديد، كان التقدم نحو الاستدامة في رفاهية الإنسان أفضل. ارتفعت الدرجات من ٥٥ نقطة في عام ٢٠٠٩ إلى ٩٥ نقطة في عام ٢٠١٦ مما يشير إلى تقدم ممتاز. ومع ذلك، كان التقدم نحو الاستدامة في الرفاه البيئي ضئيلاً. ارتفعت الدرجات من ٤٢ نقطة في عام ٢٠٠٨ إلى ٦٧ نقطة فقط في آخر ثلاث سنوات (٢٠١٥–٢٠١٧) مشيراً إلى تقدم بطيء وأقل من المتوسط. أشارت النتائج إلى أن عام (٢٠١٦) حقق أفضل المكاسب نحو الاستدامة وأن تدابير الإدارة و / أو الممارسات المعتمدة في عام ٢٠١٦ كانت لصالح التنمية الاجتماعية والاقتصادية أكثر من الحفاظ على البيئة. أكد تحليل الحساسية أن عام ٢٠١٦ كان العام الأكثر تفضيلاً وقدم نقاط قوة ونقاط ضعف مختلفة لتحسين رفاهية الإنسان والبيئة وبالتالي تحسين التقدم نحو الاستدامة. لذلك، تُنصح السلطة الإدارية بتكييف تدابير تحفظية لتعزيز البيئة وحمايتها. حيث أنه وعلى المدى الطويل، قد تهدد تفضيلات رفاهية الإنسان على البيئة المصايد بأكملها.

الكلمات المفتاحية: التنمية المستدامة لمصايد الأسماك، تحليل الحساسية، إطارالتنمية المستدامة بيئياً، مصايد الباطنة

Introduction

The recognition of the concept of sustainability is a critical need in order to manage any sector including fisheries (Michael et al., 2014). It had a notable discussion during the last few decades since it concerns the principles of conserving all natural resources for the current and future generation needs. Fisheries management's thoughts raised globally as a result of the growing of fishery sector importance for human life in providing food, employment, income etc. Therefore, several frameworks were developed to assess the progress toward sustainable development (Coll et al., 2013; FAO, 1999; Fletcher et al., 2005; Levrel et al., 2009). One of these frameworks is the Ecologically Sustainable Development (ESD) framework, which is used in this study. ESD framework structure is similar to the general sustainable development framework which reflects the human and environmental components (FAO 1999). It represents the effects of fishing activities on human and

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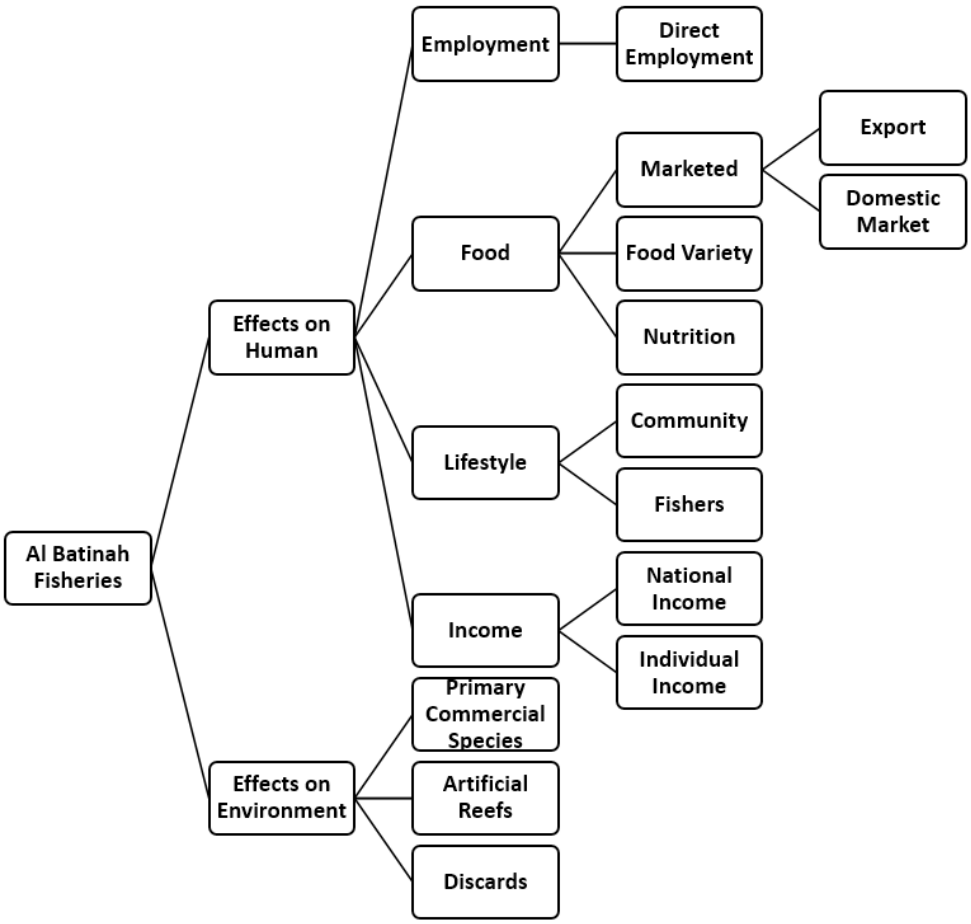

Figure 1. ESD hierarchical structure for Al Batinah fishery generated by Hiview software

environment. In addition, ESD framework establishes the hierarchy structure of components, in which each component in the framework can be subdivided further into several criteria or indicators (FAO 1999).

Multi Criteria Decision Analysis (MCDA) is used to provide a method of scoring alternative decision in term of their importance of various preferences (Stoycheva et al. 2018). Moreover, MCDA provides an overall ordering options, from the most preferred to the least preferred option (Communities 2000). These options are differing in the extent and they achieve the objectives and no option will be the best in achieving all objectives (Communities 2000). MCDA methods involve several theories; one of them is called Analytical Hierarchy Process (AHP) that is adopted in this study. Oman is characterized as poor fisheries data available (Al Masroori and Bose, 2016; 2021), MCDA can deal with incomplete data and uncertain information to give the overall trend of sustainability. In addition, the hierarchical structure provided by AHP method will facilitate the comparison between the ecological aspects with socio economic ones at the same framework (Mendoza and Martins 2006).

Hiview software (Catalyze 2003) is also used in the current study to solve large and complex MCDA problems (Communities 2000). It allows the value tree to be visually created and edited. The top of it called the Root Node, where all data in the model is collated. Out of the Root Node there are branches that represent the objectives. The criteria are structured under the nodes: effects on human and effects on environment (Catalyze 2003; Al Masroori 2008). Further information can be found in the reference by Catalyze (2003). In the current study, Hiview software is hired to assess the progress of each component toward sustainability and to conduct sensitivity analysis in order to identify strengths and weaknesses of all identified components that contribute positively or negatively to the progress of both human and environmental well-beings toward sustainability.

All components were weighted equally. Thus, the two main categories of the framework had been given a weight of 50%. Each component under the main category had given a weight also. Then, for each indicator a preferred score was selected and the standardize index was calculated for each component. Thus, the weight summation for any component is the average of its crite-

ria weight. Then, the weight summation was determined for each component for the two main categories (Chesson et al 1999). Therefore, the same weight was given for each criterion under the same component assuming an equal consideration toward human and environmental well-being. This software analysis provides some signs about the criteria sensitivity for weight change. The aim of this study was to assess the sustainability progress of Al Batinah fishery using MCDA.

The Sultanate of Oman is a coastal country with a long coastline that stretches about 3126 km long. Therefore, fishing is an old and important occupation in Oman's communities and contributes to the public economy and fishermen income especially as Oman is considered one of the largest fish producers and exporters in the region (FAO 2019). Oman's fisheries produced around 840,000 tons of fish in 2020 and exported around 283,000 tones out of the total landing. Moreover, fishing sector plays a vital role in providing a food source, employing people and contributing to the country's Gross Domestic Product (GDP). Fishing activity in Oman depends fundamentally on marine capture, which provides around 94% of the total landing produced by traditional fishery (MAF 2020). On the other hand, fishing sector's contribution to the country's GDP is still weak. It did not exceed 0.9% only in 2019 (MAF 2020) and it is obvious that this sector needs an advance management and assessing the sustainability of the traditional fishery in Oman and it should be a prime concern for the fisheries authority. In this regard, this paper takes Al Batinah Governorate as a case study due to the availability of data compared to other governorates and for its contribution to the Omani artisanal fishery landing. Among all other eleven governorates, Al Batinah came in the fourth place after Al Wusta, Sharqiah and Dhofar according to its contribution (10%) to the total landing (MAF2020). It has more than (14,500) fishermen working on about 6300 boats (MAF 2020). The most important fishes caught in Al Batinah are yellowfin tuna, longtail tuna, sardine and anchovy (MAF 2020). Furthermore, Al Batinah has a unique characteristic, which are the artificial reefs. They were deployed in 2003 as a trial to boost the declined fisheries sector and enhance the ecosystem in the region.

Methodology

To assess the progress of Al Batinah fishery toward sustainability, a modified version of the ESD framework developed by Chesson and Clayton (1998) was followed. The modification was done through a consultation review was designed and discussed with the stakeholders. Consulting key stakeholders to identify the issues of the base ESD framework is a vital step to ensure that the context of the ESD framework tree would be functional within Al Batinah fisheries sector. The consultation helped in identifying all possible components of the hierarchical structure, maximizing consistency and minimizing the chance of missing any issues or impacts (positive or negative) and gaining the acceptance of all stakeholders.

The modified ESD framework was distributed and explained personally with 19 experts covering different levels of fisheries stakeholders; 8 academics, 6 managers and 5 researchers in the field with a response rate of 58%. As shown in the Figure 1, framework has two main components, namely the effects on human and the effects on environment. These two components were further divided into sub- components, which were identified through the consultation meetings with stakeholders. The specified objectives and indicators with their preferred trends and reference points developed by Al Masroori and Bose (2009; 2014), following FAO (1999) technical specifications, were used as basis in this study (Tables 1 and 2). The objectives were specified with respect to the national regulations and international legislation and conventions in the Sultanate. Data was obtained from fisheries statistical books from MAF (2008 – 2017), the Statistical Department in MAF, the Directorate General of Fisheries in Al Batinah and the National Centre for Statistics and Information (Tables 3, 4 and 5).

In addition to that, the weighted summation method (Al Masroori, 2008) was followed to evaluate the progress toward sustainability over the study period 2008 to 2017). For the current study, the same weight was given for each criterion under the same component assuming an equal consideration toward human and environmental well-being. The best value given for each indicator was depending on the objective specified for it. The score for any component of the ESD tree was determined to be as the weight sum of the sub-components belongs to it using the following formula (Chesson and Clayton 1998):

(1)

$$\sum_{j=1}^{n} w_j u_{ij}$$

Where: j represents ESD component, i represents time, wj the weight for component j, u_j is the score for component j in year i. As mentioned earlier, all components were weighted equally. Thus, the two main categories of the framework had been given a weight of 50%. Each component under the main category had given a weight also. Then, for each indicator a preferred score was selected and the standardize index was calculated for each component. Thus, weight summation for any component is the average of its criteria weight. Then, weight summation was determined for each component for the two main categories (Chesson et al. 1999). For each component in the ESD framework, weight average for each year of the study period was calculated using

Table 1. Indicators used for each component of the effects of Al Batinah fisheries on Human during the period (2008 – 2017)

Component	Objective	Indicator	Required Data
Food			• Total catch in Al Batinah per year
Nutrition	Enhancement of food security from fishing sector	Fish per capita (kg)	• Total population in Oman
Variety	Increase the number of species come from Al Batinah fishery	Total number of species caught in Al Batinah (mt)	• Annual total number of species caught in Al Batinah
Marketed Domestic	Increase the local consumption of Al Batinah fishery production	Total amount of Al Batinah fishery consumed locally (mt)	• Annual percentage of Al Batinah fishery production consumed locally
Export	Decrease the exported amount of Al Batinah fishery production	Total amount of Al Batinah fishery exported (mt)	• Annual percentage of Al Batinah fishery production exported
Income			
Individual	Increase fishers' income	Annual income of Al Batinah local fishers (OR)	• Annual catch value gained by local fishers
National	Improve country income	Annual contribution of Al Batinah fishery to the country GDP (OR)	• Fishers licenses fees • Boats licenses fees • Tracks licenses fees • Fishing institutions fees • Fishing gear fees • Artificial reef fees • Technicians on vessels fees
Life style			
Fishers	Enhancement of fishers' lifestyle	Number of boats owned by fishermen	• Number of boats owned by fishermen each year
Community	Enhancement of communities' lifestyle	Number fishing tracks in Al Batinah	• Annual number of fishing tracks in Al Batinah
Employment Direct	Increase the number of Al Batinah local fishers	Total number of local fishers in Al Batinah	• Annual total number of Al Batinah local fishers

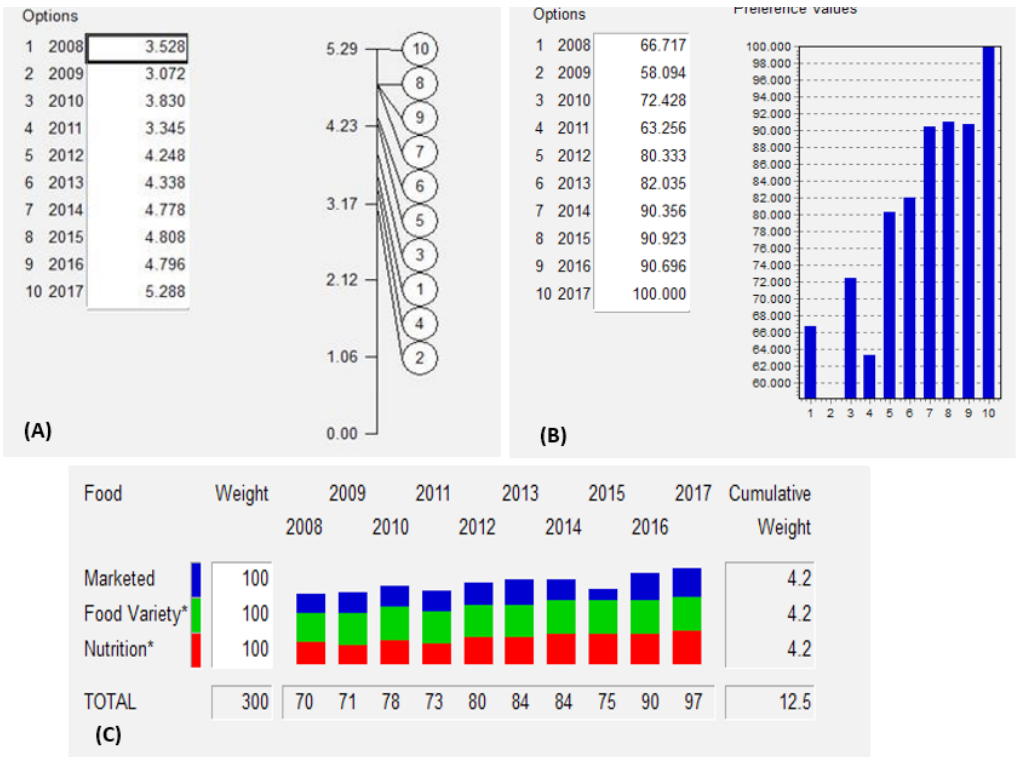

Figure 2. A) Nutrition criterion data (kg), B) Preference values of nutrition criterion for food component, and C) Weight scores and contributions of food component

Table 2. Indicators used for each component of the effects of Al Batinah fisheries on Environment during the period (2008 – 2017)

Component	Objective	Indicator	Required Data
Primary commercial species			
Abundance of target species	Control the target species catch to preserve them against over-exploitation	Landings (mt)	Total catch of target species per year
Non- target species			
Discard	Minimize the amount of discarded fish in Al Batinah	Annual amount of discarded fish in Al Batinah (mt)	• Total annual amount of discarded fish in Al Batinah
Other aspects			
Artificial reef	Enhancement of fish biodiversity in Al Batinah	Number of artificial reef units deployed in Al Batinah	• Annual total number of artificial reef units deployed in Al Batinah

Hiview Software.

The results were examined using Hiview software © version 3.2.0.9 (a Multi-Criteria Decision Analysis tool) to evaluate the progress of Al Batinah fishery toward sustainability (2008 – 2017). MCDA approach is used to reduce the complexity of data in this study using the Hiview software. In addition, Microsoft Excel software was used for some basic calculations.

For further investigation of the overall results, sensitivity analysis was used to determine the most sensitive criteria for weight change. This type of analysis could help decision-makers to predict the future scenario for the current situation and consequently, they can change their actions to maintain the suitable status of the fishery. For the current study, sensitivity analysis was carried out to investigate the preferred year within the study period and its strength and weakness. More details about sensitivity analysis can be obtained in (Al Masroori, 2008).

Results and Discussion

The ESD framework of Al Batinah Fishery was developed and analyzed following the steps addressed by Chesson and Clayton (1998) and Communities (2000). The final framework used in this study is shown in Figure 1 as built by the Hiview. It is worth noting that some components in the ESD hierarchical structure were eliminated from the analysis due to the unavailability of representative data such as pollution, seascape, fish biodiversity and post-harvest indicators. This is considered as a limitation to this study and hence the concerned authori-

Table 3. Data and preferred score of effect on human component indicators

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Preferred score
Nutrition (kg) per capita fish consumption	3.528	3.072	3.830	3.345	4.248	4.338	4.778	4.808	4.796	5.288	5.288
Food variety (H) Shannon Diversity Index	87.51	96.57	100.00	93.98	93.93	95.72	97.85	98.48	98.18	98.96	100.00
Domestic Market (mt) Catch consumed locally	19197.1	18727.7	20592.2	21370.1	29840.9	33101.9	36213.7	35098.8	41910.5	48229.2	48229.2
Export (mt) Catch exported outside the Governorate	1444.9	1195.4	1083.8	1124.8	1570.6	1023.8	2725.8	5713.8	1296.2	984.3	984.3
Individual income (000 OMR) Catch value gained by local fishers	14	19	19	24	37	42	47	43	51	56	56
National income (OMR) Contribution of Al Batinah fisheries to the country GDP	38488.9	33717.5	55164.9	39597.3	49743.9	63901.2	40289.6	39540.5	68107.5	74687	74687
Fishers lifestyle (boat) Number of boats owned by local fishers	4704	4080	4796	4852	5025	5294	5754	5996	6087	6144	6144
Community lifestyle (licenses) Number of tracks licences issued for fish transporting and marketing	470	500	557	575	601	629	719	780	1636	897	1636
Direct Employment (Omani) Number of local fishers	12036	8764	10028	10887	11943	12675	13166	13546	13834	14216	14216

Table 4. Data and preferred score of effect on environment component indicators

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Preferred score
Primary commercial species (mt) Total catch of primary commercial species	20642	19923	21676	22495	31411	34126	38939	40813	43207	49213	49213
Discard (mt) Total discarded fish	206.42	199.23	216.76	224.95	314.11	341.26	389.39	408.13	432.07	492.13	0
Artificial reef (unit) Total number of artificial reef	1374	1874	2374	4774	5174	5294	5294	5358	5358	5358	5358

Table 5. Total catch and the amounts of total catch consumed locally and exported (mt) (2008 – 2017)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total catch (mt)	20642	19923	21676	22494.842	31411.442	34125.657	38939.454	40812.603	43206.676	49213.499
Amount used in domestic market (mt)	19197.06	18727.62	20592.20	21370.10	29840.87	33101.89	36213.69	35098.84	41910.48	48229.23
Amount export (mt)	1444.9	1195.4	1083.8	1124.742	1570.572	1023.7697	2725.7618	5713.7644	1296.2003	984.2699
Number of species	36	37	37	37	36	36	38	37	38	37

ties are recommended to start gathering such important information. Tables 1 and 2 show the criteria, objectives, indicators and required data used for the case study analyses (Al Masroori and Bose, 2009). Food component will be taken as an example to explain the process of analyzing. As shown in Table 1, food component was classified into three sub-components: nutrition, food variety and marketed which were divided further into: domestic market and export. Per capita fish consumption was used as an indicator for nutrition sub-component. The

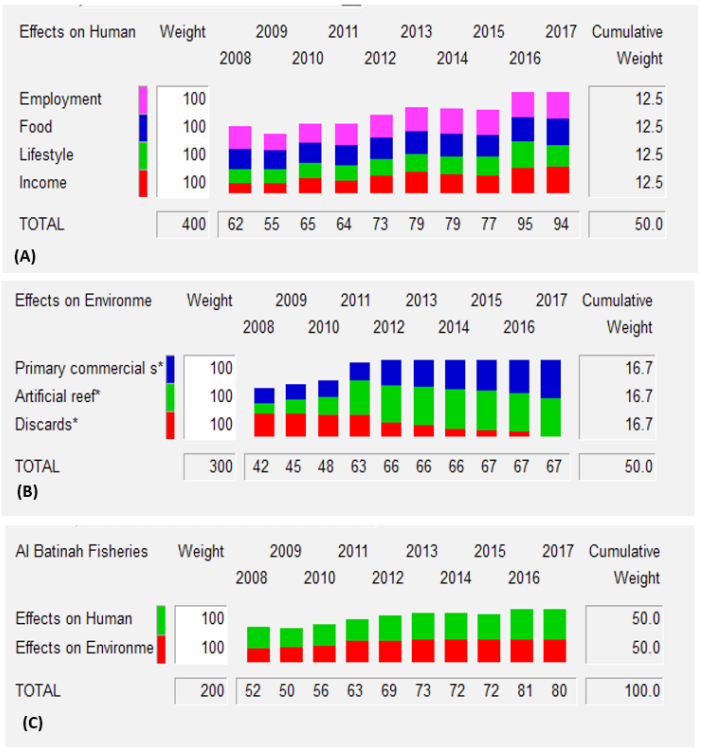

Figure 3. Weight scores and criteria contributions of effect on; A) human component, B) environmental component and, C) from both human and environment components

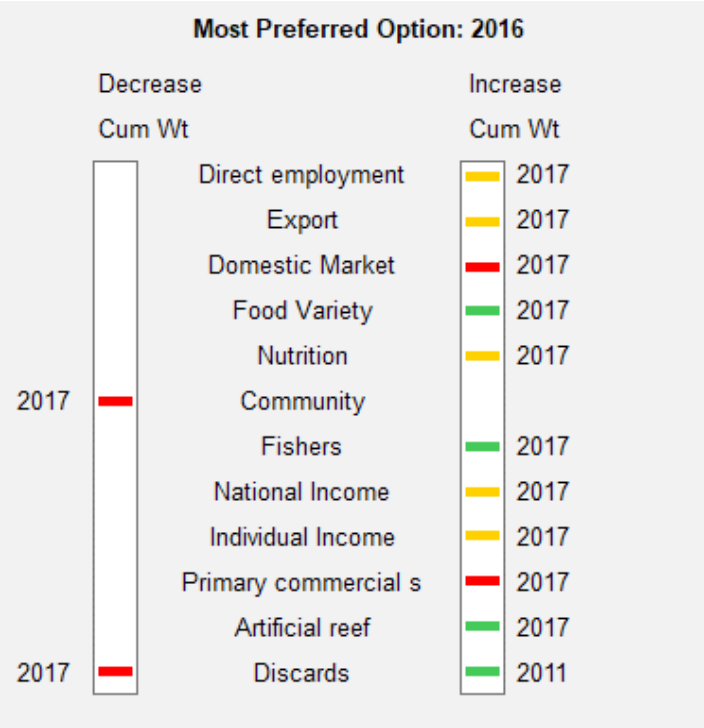

Figure 4. Most preferred year (sensitivity down)

trend for the nutrition sub-component indicator is preferred to be positive. Figures 2A and 2B show standardized data and scoring process relative to the preferred value of the nutrition sub-component. It is clear from Figure 2 that the highest score 100 was assigned to the year 2017 with the value of 5.288 kg. All other preference values were relative to 2017. On the other hand, the lowest score (58.094) which assigned the value (3.072) was recorded in 2009. More explanation about figures reading can be found in (Al Masroori and Bose, 2014).

All other sub-components of food component were analyzed following the same way and then, weighted summation method was applied for all food's sub-components. As it was mentioned earlier, all food criteria have the same weight so, no preference of one criterion over another. Figure 2C represents the data, weight scores and the contribution of each criterion for each year. It is clear that the best food trend was achieved in 2017 when most of the food sub-components achieved the peak. The year 2017 was characterized by the higher level of total catch during the study period, which affects all food components positively. The same steps were followed in analyzing all other components in the ESD framework to examine the progress toward sustainability.

Overall Results

As shown in Figure 3A, year 2016 scored the highest preferred value of 95 for the effect on human. While year 2009 scored the lowest as 55. On the other hand, Figure 3B shows that the years 2015 (with 2016 and 2017) scored the highest preferred value as 67 for the effect on environment and 2008 scored the lowest value of 42. A similar trend (increasing) is almost happening in both dimensions. This is supported by the overall comparative assessment between human and environment components, where year 2016 scored the highest preferred value of 81, with a major contribution from the human components (Figure 3C).

Generally, the results of this study indicated that higher priority was given by the government toward the human benefits in 2016 and the management policies applied favored what is considered as a short-term benefit. In general, all human components were improved from 2008 to 2017 due to the concentration of the government on the sector as one of the promising economic sectors in the country. It is allocating 500 million OMR to support the Strategic Plan for the Development of the Fishing Sector from 2013 to 2020, which has been implemented by the Ministry of Fishery (MAF).

It is obvious that all the National Fisheries Development Strategy from 2013 to 2020 are concentrated toward human benefits. By 2020 the total landing in Oman was around 840,000 tonnes (MAF, 2020) and there were around 60 fish markets and 26 harbors (MAF, 2020) around the country to meet the national strategy objectives. Although no single objective has been related to the environmental protection or stocks conservation in the Strategy. Environmental well-being was also

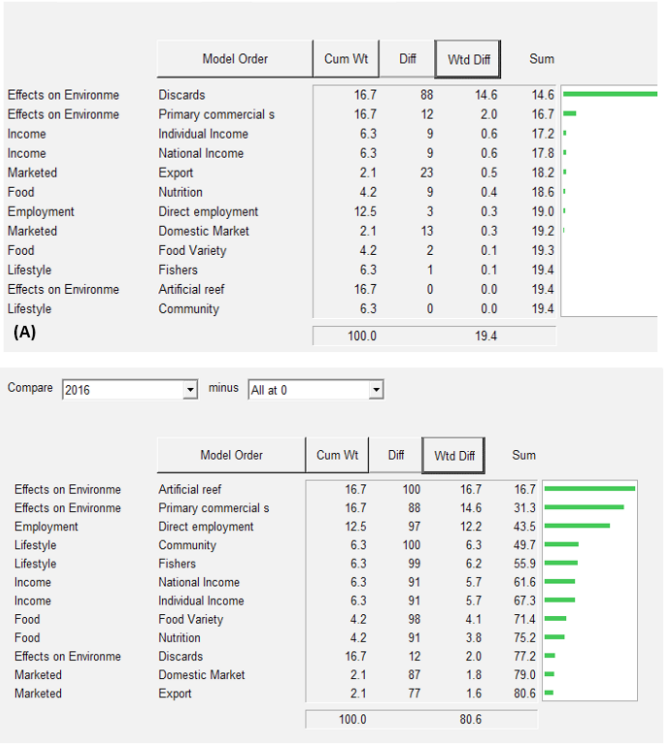

Figure 5. A) Weaknesses and B) Strength of the most preferred year (2016)

progressing in an increasing trend but not as well as in human well-being (Figure 3). This study shows a similar trend of favoring the human wellbeing over the environmental wellbeing that was also found in Al Masroori and Bose (2021) for an industrial fishery. This indicates a similarity in the management strategies for traditional and industrial fisheries and a little change in the management structure.

Sensitivity Analysis

Based on the overall results shown in Figure 3C, the most preferred year was 2016 followed by 2017. Figure 4 confirms this by sensitivity down analysis. The figure lists the criteria at the middle and different coloured bars indicate which criteria are the most sensitive for weight change. Figure 4 shows that 2017 could override year 2016 if the weights of food variety, fishers' lifestyle and artificial reefs are increased by more than 15 points. Also, it is clear that 2017 could override the year 2016 if the weights of direct employment, export, nutrition, individual income and national income are increased between 5-15 points. On the other hand, the same figure shows that 2017 can override the year 2016 if the weights of domestic market and primary commercial species are increased by less than 5 points and the weights of community lifestyle and discards are decreased by less than 5 points. Figures 5A and 5B are called sort graphs that are used usually to compare the performance of two options (years) and examines the strengths and weaknesses in any options. Figure 5A shows the weakness of the most preferred year 2016. It is clear that most of the weak components of year 2016 are in the environmental sector especially in discards and primary commercial species. Discard component contributed a lot to the weakness of the most preferred year. On the other hand, it gained its strength from both environmental sides in artificial reefs and primary commercial species along with human components dominated by direct employment, lifestyle component, income component, and nutrition and food variety of the food component (Figure 5 B). Generally, it can be stated that the year 2016 was stronger in human sides and short-term benefits than conserving the environment.

A similar further analysis was done to investigate the human component using sensitivity up analysis, Figure 6A shows that the year 2016 is the most preferred year for the effect on human component and it is very clear that decreasing the weight to almost 0% will only change the year to 2017. Sensitivity analysis was also applied for environmental component as shown in Figure 6B. It can be seen that 2016 is also the most preferred year for the effect on environment component and only year 2017 can override the year 2016 if the weight of the effect of environment component is increased to almost 100% as shown by the shaded area in Figure 6B. These trends (the dominance of the year 2016 over all other years indicate that the management measures practiced in year 2016

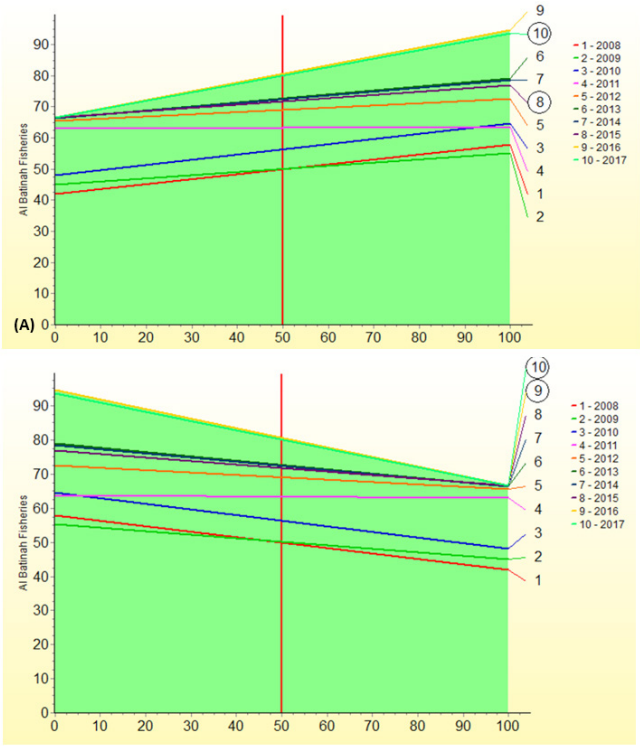

Figure 6. Sensitivity up of effect on; A) human component and B) environment component

were the best among the investigated year.

Conclusion

The progress of Al Batinah fishery toward sustainability showed a positive trend. The results revealed that the year 2016 had the best attainment toward sustainability. Generally, the above results indicated that the management measures practiced in 2016 were the best in terms of human components and short-term benefits (food, income, lifestyle and employment) rather than conserving the environment. This give an indication that the management authority was preferring the human well-being over the environmental well-being, which means it is progressing away from sustainable development. Sensitivity analysis confirmed that year 2016 was the most preferred year in the assessment between year 2008 and 2017 and the year 2017 could override it if some criteria weights have been changed.

Recommendations

Based on the main findings and limitations encountered in this research, the following recommendations are proposed to promote the sustainable development of the fisheries sector in Oman in general: (i) Accurate and specific data representing fishery indicators like: post-harvest data, pollution, sea scape etc in the sector is a critical need for better assessment. (ii) The qualified fishery indicators such as fish biodiversity are important to be considered by the fishery authority. (iii) More attention needs to be applied to the environmental well-being like: preserving stocks, reduce pollution level and minimize the destruction of marine habitats in preparing the future Fisheries Strategic Plans. (iv) Establishing a unit to organize and coordinate the joint work between MAF and EA (Environment Authority) might strengthen the environmental protection and therefore enhance the sustainability.

References

Al-Masroori HS. (2008). An Assessment of the Commercial Trawl Fishery of the Sultanate of Oman using the Ecologically Sustainable Development Framework; an evaluation study, PhD thesis, University of Tasmania, Australia.

Al-Masroori HS, Bose S. (2009). Developing indicators for the assessment of sustainability of an industrial fishery: a case study in the Sultanate of Oman. Egyptian Jornal of Aquatic Research 35(2): 189–197.

Al-Masroori HS, Bose S. (2014). Towards developing index for the assessment of sustainable development: a case study of the Sultanate of Oman. In proceeding of the Seventeenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET), pp. 7-11.

Al-Masroori HS, Bose S. (2016). Anchoring to determine negotiated catch limits: a case study of an industrial fishery in Oman. African Journal of Marine

Science 38(1): 101-109.

Al-Masroori HS, Bose S. (2021). Fisheries sustainability assessment and sensitivity analysis: an illustration. Environment, Development and Sustainability 23: 16283-16303.

Catalyze. (2003). Hiview 3: Enabling effective decisions (Starter Guide) Catalyze Ltd.

Chesson J, Clayton H. (1998). A framework for assessing fisheries with respect to ecologically sustainable development. Bureau of Rural Sciences, Canberra, Australia.

Chesson J, Clayton H, Whitworth B. (1999). Evaluation of fisheries- management systems with respect to sustainable development. ICES Journal of Marine Science 56(6): 980-984.

Coll M, Libralato S, Pitcher T, Solidoro C, Tudela S. (2013). Sustainability implications of honouring the Code of Conduct for Responsible Fisheries. Global Environmental Change 23: 157–166.

Communities. (2000). Multi-criteria Analysis Manual. UK. National Economic Research Association.

FAO. (1999). Indicators for Sustainable Development of Marine Capture Fisheries. FAO Technical Guidelines for Responsible Fisheries, Rome.

FAO. (2019). Fishery and Aquaculture Country Profiles, The Sultanate of Oman. Retrieved from http://www.fao.org/fishery/facp/OMN/en

Fletcher WJ, Chesson J, Sainsbury KJ, Hundloe TJ, Fisher M. (2005). A flexible and practical framework for reporting on ecologically sustainable development for wild capture fisheries. Fisheries Research 71(2): 175–183.

Levrel H, Kerbiriou C, Couvet D, Weber J. (2009). OECD pressure–state–response indicators for managing biodiversity: A realistic perspective for a French biosphere reserve. Biodiversity and Conservation 18(7): 1719–1732.

MAF. (2020). Annual Statistics Report for 2020. Ministry of Agricultural and Fisheries Wealth, Muscat, Oman. Arabic.

Mendoza G, Martins H. (2006). Multi-Criteria Decision Analysis in Natural Resource Management: A Critical Review of Methods and New Modelling Paradigms. Forest Ecology and Management 230: 1–22.

Michael FL, Noor ZZ, Figueroa MJ. (2014). Review of urban sustainability indicators assessmentâ ”Case study between Asian countries. Habitat International 44: 491–500.

Stoycheva S, Marchese D, Paul C, Padoan S, Juhmani A, Linkov I. (2018). Multi-Criteria Decision Analysis Framework for Sustainable Manufacturing in Automotive Industry. Journal of Cleaner Production 187: 257–272.