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Selecting priorities, indicators and criteria to monitor sustainable aquaculture development: lessons learned from selected case studies in the Mediterranean

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ABSTRACT

Recently, there is increased interest in the sustainability of aquaculture in the Mediterranean due to the rapid expansion of the sector in the past decades. The use of clear indicators linked to higher level criteria that characterize the associated principles of sustainable development, is considered one of the most appropriate ways to monitor and assess the sustainability of aquaculture activities. In this study, analyzed the main outcomes of a comprehensive project implemented by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) called "Indicators for the sustainable development of aquaculture and guidelines for their use in the Mediterranean" (2008-2015). The development of case studies at the local level based on a "PCI" (Principles-Criteria- Indicators) approach has helped to identify the main steps in building local consensus on the selection and assessment of aquaculture indicators together with key stakeholders. In the case studies, 156 selected indicators and related criteria were ranked by local stakeholders based on their perceptions and understanding of local priorities. The order of relevance assigned to indicators for each of four "pillars" of aquaculture sustainability (governance, social, economic and environmental) was analyzed. Furthermore, the project confirmed that the identification of indicators and criteria is a dynamic process that when is considered in a selected area evolves with

local aquaculture development and environmental thinking as a whole. The aim of this paper is to describe how the identification of criteria and use of aquaculture sustainability indicators in the Mediterranean have been applied in selected coastal aquaculture communities that also reflect different levels of aquaculture development.

K E Y W O R D S: Aquaculture,Sustainable development,Mediterranean Sea,Indicators.

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1. Introduction

Fisheries and aquaculture are key sources of food, nutrition, income and livelihoods for hundreds of millions of people around the world, with aquaculture now providing more than half of all fish for human consumption (FAO, 2018a). Aquaculture in the Mediterranean and Black Sea holds great potential to provide multiple benefits if managed in a responsible way. On the other hand, one of the biggest challenges for aquaculture industry managers and policymakers today is to ensure that the aquaculture industry is economically, environmentally, and socially sustainable, and to involve all sector actors in the process of achieving these multiple benefits (Caffey et al., 2001; FAO, 2011; Valenti et al., 2011). This includes minimizing "negative externalities" or their environmental footprint (Massa et al., 2017). In 1995, the Code of Conduct for Responsible Fisheries (CCRF) of the Food and Agriculture Organization of the United Nations (FAO) (FAO, 1995) prompted increased national level awareness on the need for aquaculture to be developed sustainably. In addition to the environmental dimension, the social dimension is also essential for the sustainable development of aquaculture and local actors play an important role in promoting the social acceptability of aquaculture, in particular by coastal communities (Hishamunda et al., 2014). These "people" and "planet" dimensions of sustainability, especially their integrated nature, have recently been reinforced in the 14th Sustainable Development Goal (SDG) of the 2030 Agenda for Sustainable Development, adopted by the United Nations Summit in 2015. They are an integral part of the Blue Growth (European Commission, 2012b) as well as of the FAO Blue Growth Initiative (FAO, 2015). However, the recent expansion of aquaculture has also brought to the public attention certain environmental and socio-economic issues linked to the sustainable development of the sector[1] (Fezzardi et al., 2013).

Within this context, a widely recognized way of measuring and monitoring progress towards sustainable aquaculture is to apply specific criteria and related indicators that link different aquaculture dimensions (Caffey et al., 2001; Degnbol, 2005; Pullin et al., 2007; Ceriola et al., 2008; Valentin and Spangenberg, 2000; FAO, 2011; Valenti et al., 2011; Valenti et al, 2018, Fezzardi et al., 2013). This article holds that an indicator is an observed value representative of a studied phenomenon (Gabrielsen and Bosch, 2003) and the use of a pool of indicators provides a link between objectives and actions to achieve them (Ceriola et al., 2008). According to the purposes of the assessment an indicator could be intended as: a quantitative or qualitative value, variable, or index (FAO, 1999); a tool for monitoring, evaluation, forecasting and decision support (Madec, 2003); a parameter or value providing information and describing a given phenomenon (OECD, 2003); an internal or external communication vector, related to a standard value (Chia, 2010). The basic functions of an indicator are to simplify and quantify complex phenomena in order to easily communicate certain information, and its ideal characteristics include being measurable and achievable support decision-making cycle, including problem identification, policy formulation, implementation and/or policy evaluation (Ceriola et al., 2008; Valentin and Spangenberg, 2000; Valenti et al., 2011; Valenti et al, 2018, Fezzardi et al, 2013; FAO, 1999).

The development and use of indicators should be considered a continuous learning process that implies better dialogue and coordination among actors (Rey-Valette et al., 2007; Chia et al., 2011; Mathé et al., 2011). This process is even more effective when based on a "principles-criteria-indicators" (PCI) approach as proposed by Rey-Valette et al. (2008). In the Mediterranean, several projects and initiatives have been working to identify suitable methods to formulate aquaculture indicators in a participatory way e.g.: the Evaluation of Aquaculture System

[1] Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO, 1997)

Sustainability (EVAD) project (Rey Valette et al., 2008), the CONSENSUS project (European Commission, 2012a), the MEDITERRANE-ON (FOESA, 2011). At the international level, the Global Aquaculture Performance Index (GAPI) provided a tool to evaluate the performance of marine aquaculture (Volpe et al., 2010).

Nonetheless, while the entire process of definition and identification of indicators has been widely described, the actual application of those indicators in aquaculture activities (e.g. private farms) remains challenging. This is mainly due to several interlinked constraints associated with i) the large number of stakeholders that need to be involved in implementation and ii) the local political, institutional and economic context to benchmark criteria and indicators. It is important to identify criteria that reflect both the contribution of aquaculture to sustainable development and also the sustainability of aquaculture itself (Mathé and Rey-Valette, 2011; Fezzardi et al, 2013).

2. Methodology and approach

The data here presented were collected as part of a broad multiyear project called "Indicators for sustainable development of aquaculture and guidelines for their use in the Mediterranean" (InDAM)[2] implemented in phases by the General Fisheries Commission for the Mediterranean (GFCM) of the FAO in Montenegro, Spain, Tunisia and Turkey from 2009 to 2015.

The identification of indicators based on EVAD methodology using the PCI approach was applied in different aquaculture communities in the Mediterranean Sea. The approach establishes a cascading relationship between: i) principles (i.e. the sustainable goals to be addressed), ii) the criteria (characterizing and breaking down the principle associated into specific themes or characteristics clarifying the variable to address) and iii) the indicators (that allow the criteria and variables to be practically measured).

Various stakeholders, including national aquaculture experts; fish farm managers; representatives from government, research institutions and non-governmental organizations (NGOs) were brought together to discuss, select and rank criteria and indicators from a preliminary basket of 156 indicators. This basket of 156 indicators for four dimensions or "pillars" of aquaculture sustainability (economic, environmental, social and governance) was identified by a multidisciplinary group of experts and stakeholders (FAO, 2011; Mathé et al., 2011). Based on this, a series of case studies in several bordering Mediterranean countries were carried out to downscale the testing of selected indicators at regional level and ranked at local level in the basis of the stakeholders' perception of local priorities and necessities.

This paper presents the process of identifying indicators linked to specific principles and criteria by stakeholders from four case study countries. For each case study, the 156 indicators were ranked in order of relevance and according their apparent priority for each of four "pillars" of aquaculture sustainability. The results were then aggregated and compared in order to arrive at an understanding of which indicators and criteria were emerging as priorities at local, national and regional levels, as well their practical implications for sustainable aquaculture development.

3. Case studies

The case studies are from Montenegro, Spain, Tunisia and Turkey, whose aquaculture sector is development in different stages of development in each of these countries. Montenegro is an example of a country, where aquaculture is little developed and constitutes a negligible proportion of the national economy, whereas aquaculture in Tunisia, at the time of the implementation of the case study, was in its infancy but considered to have growth potential. In contrast, Spain and Turkey are examples of countries with an established marine finfish aquaculture industry (Barazi-Yeroulanos, 2010).

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Montenegro case study

One case study was launched in Kotor in 2013 with the collaboration of administrative and port authorities, scientific institutions, the inspection directorate of Montenegro as well as farmers and representatives of farmers' organizations. The case study was aimed at identifying and pre-selecting indicators to be used at the farm, local and national scale through a methodology adapted to the Montenegrin context. In particular, this case study also provided an opportunity to identify criteria that could be applied in the identification of allocated zones for aquaculture (AZAs) (GFCM, 2012) in Montenegro through a system of indicators. During the implementation of case study activities, marine aquaculture was mainly based on family shellfish farming and the national aquaculture development was considered to be limited. The main challenge highlighted was that tourism, a major economic activity in coastal areas, could be the source of conflicts over the use of space during the delineation process of an AZA. In order to address this, the Montenegrin authorities acted to raise awareness among coastal users and stakeholders about the positive aspects of aquaculture beyond benefits to farmers by preparing and disseminating a video to promote the potential synergies between coastal activities and benefits of aquaculture to the tourism industry (MFilm Montenegro, 2015).

Spain case study

Activities were implemented in 2011 and this case study looks at the relevance and definition of reference points while working towards regional indicators. The basket of 156 indicators was the starting point for a selection process and was used by other development initiatives to prepare guidelines on the use of indicators in aquaculture (GFCM, 2011). The use of the Delphi[3] method and of quantitative assessments made possible to score and rank the indicators and to draw conclusions on their applicability. In addition, the Spanish Multiannual Strategic Plan for Aquaculture 2014–2020 embraced the use of indicators and aimed to assess their implementation as well as effectiveness in achieving national objectives.

Tunisia case study

Different case study activities were implemented in Tunisia (in 2009, 2011 and 2013 respectively), and these aimed at promoting a common understanding of indicators and sustainability, based on a participatory approach (i.e. "co-construction" methodology). The studies started with a workshop bringing together all stakeholders involved in aquaculture (researchers, farmers and administrations), where contributors had provided remarks and comments on each indicator. The workshop aimed to test the applicability and the use of indicators at the farm level and to verify whether they needed to be further refined or adapted to local production conditions. Several exercises were carried out with farmers to raise awareness on sustainability as well as production issues. Over 90% of Tunisian farmers practicing marine cage aquaculture were involved in the case studies.

Turkey case study

Two case studies were launched (in 2009 and in 2011 respectively) after two meetings where experts had agreed on a first basket of aquaculture indicators. The two case studies aimed to review, prioritize and narrow down the initial basket of 156 indicators, to obtain a common definition for each indicator, to develop methodological sheets and to define reference points to monitor and assess the trends of the indicators. The exercise was carried out by establishing focus groups for the three dimensions of sustainability plus the governance facet and by involving a wide range of stakeholders, including non-governmental organizations (NGOs), administrators, researchers and aquaculture farmers. The process resulted in a final shorter list of indicators with a limited number of attributes to score the indicators following a quantitative approach. This experience has enhanced dialogue among stakeholders and in raised awareness of sustainability issues, underlining that a wide representation of stakeholders is important to identify different

[3] Structured communication technique or method, originally developed as a systematic, interactive forecasting method which relies on a panel of experts (Dalkey and Helmer, 1963).

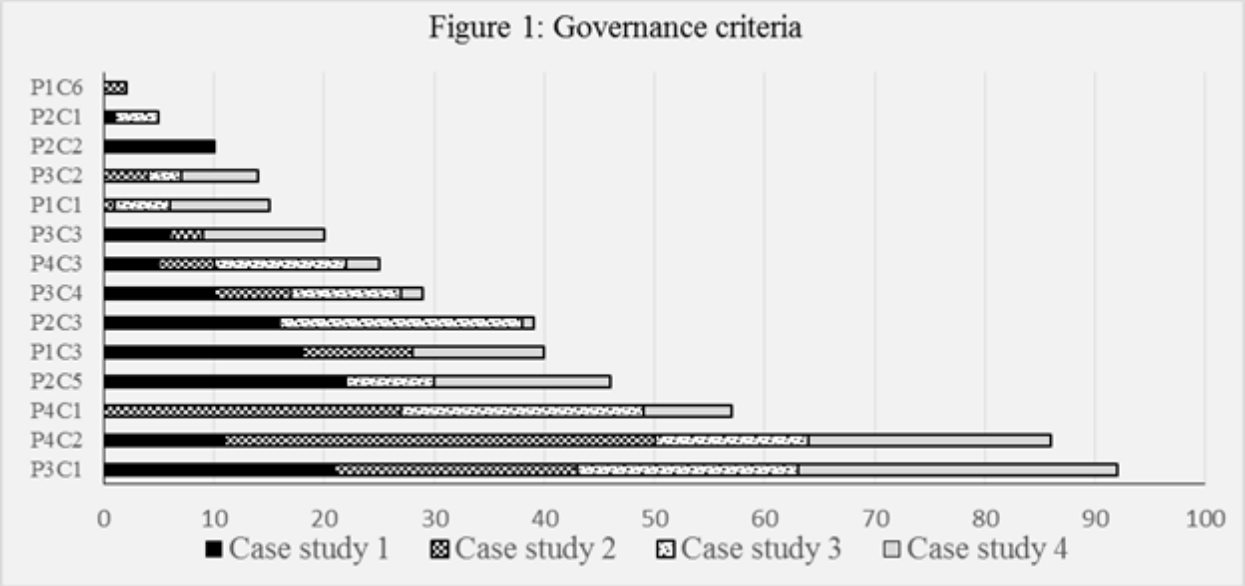
perceptions of various stakeholders, and thus promote the social acceptability of aquaculture. Turkey advanced even further building upon its national experience on the use of indicators. New activities were carried out recently at the local level in Muğla and Izmir where marine cage aquaculture is well established. The objective was to identify appropriate indicators to monitor the progress of sustainable aquaculture. The methodology used was the same and included a questionnaire, a scoring system and the set of indicators. Fish farmers were informed about indicators, criteria and principles and how they could be used at the local level to monitor aquaculture activities. After the initial pre-selection of a set of relevant indicators, a survey to score the indicators and assess their applicability was carried out among fish farmers.

4. Results

The results are presented below by each "pillar" of sustainability. Bar graphs show the total value assigned to each criterion by all case study countries together, as well as the breakdown of the value assigned by each case study country. See Annex 2 for the full list of criteria and their descriptions. In some countries, the process supported a more enabling environment for aquaculture activities and refreshed awareness of the existence and usefulness of indicators linked to criteria for sustainable aquaculture at the local/national level. Critically, the process also boosted understanding and acceptability of aquaculture indicators by local farmers, who were initially reluctant to test their implementation. In addition, following the implementation of the case studies presented here, national and local authorities showed increased interest in collaborating on aquaculture-related issues such as integrated coastal zone management. All references to countries below refer purely to the case studies in those countries at the moment when such studies were carried out.

Governance pillar

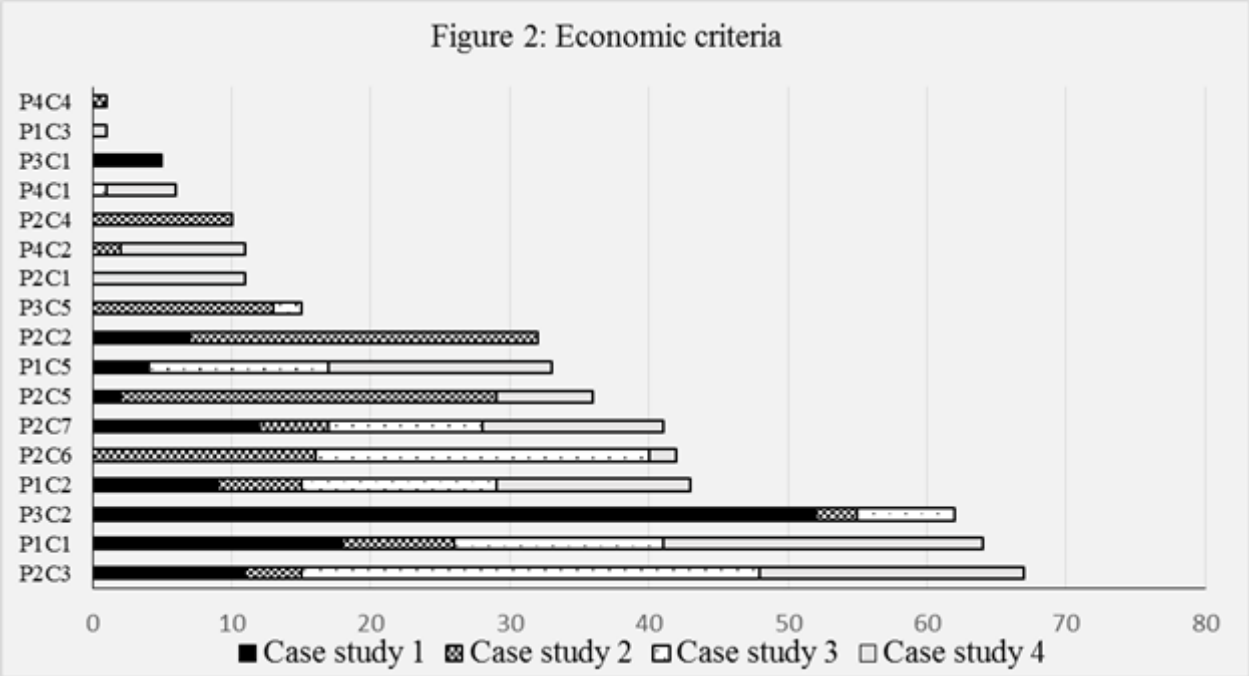
With regard to the Governance dimension (Figure 1), *the importance of research and training in aquaculture* (P3C1) and *the level of involvement of the state in the implementation of sustainable development* (P4C2) emerged as the two main common criteria driving sustainable aquaculture development in the four countries. This reflects precisely the situation in the Spain case study but only partially reflects the situation in the Turkey and Tunisia case studies. The rankings for the governance dimension clearly show how these countries are undertaking the same process, yet are at different levels of aquaculture development and therefore have different priorities. In the Spain case study, the emphasis at the time of the analysis is on *the level of management and regional planning* (P2C5), which suggests a more advanced industry compared to Tunisia, where the stress is on *the level of national recognition of sustainable development* (P4C1). *The level of participation* (P2C3) and the above-mentioned P4C1 differentiate the Montenegro case study from the other case study countries; in a country where aquaculture is not a highly productive sector, more importance has been given to criteria related to social inclusion and recognition of the sector.



Key: case study 1 (Turkey), 2 (Tunisia), 3 (Montenegro) and 4 (Spain)

Economic pillar

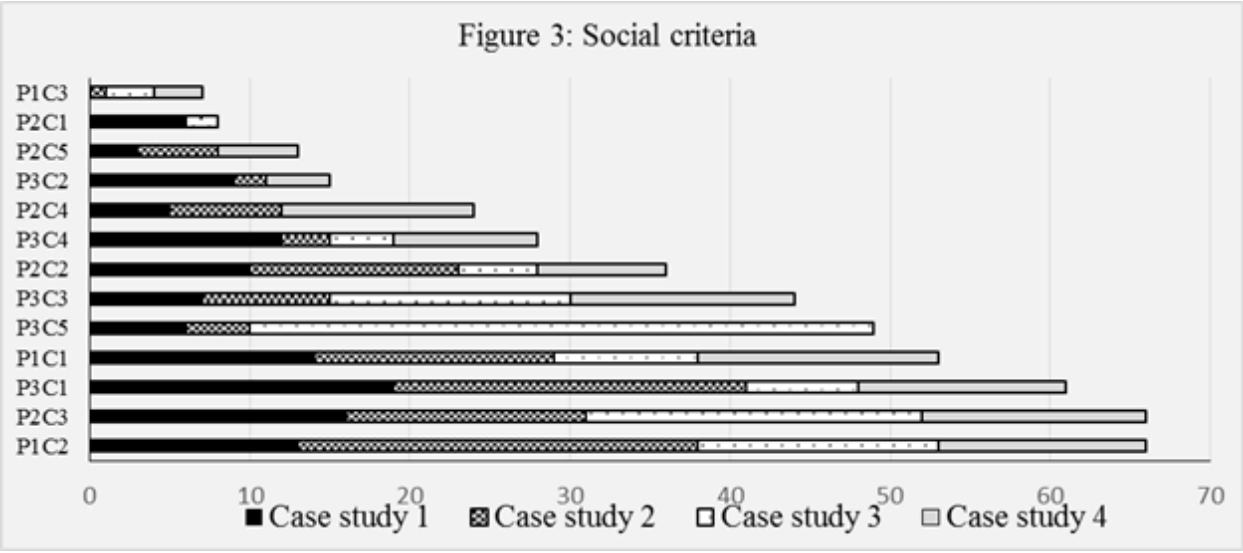
With respect to the Economic pillar (Figure 2) *the capability to monitor and challenge pathological hazard* (P2C3) is crucial as well as *the use of branding or quality assurance schemes/labels* (P1C1) and *traceable products* (P1C2) to satisfy the demands of the food market and safe production methods. These are also the main criteria highlighted by the Spain case study which, having an organized industry, put forward these criteria to control potential future biological hazards and strengthen the market. The Turkey and Montenegro case studies also include in the highest part of their ranking *the level of input efficiency* (P3C2) at farm level (e.g.: feed, labour and fry costs per kg produced; and *the level of awareness of natural hazard* (P2C6) at farm and national level (e.g.: ratio of insurance costs against total sales; use of ISO 14 000; availability of emergency funds; legislation on environmental monitoring programme) showing similar priorities in dealing with biohazards and in promoting sustainable production. On the other hand, the Tunisia case study concentrates on the relevance on *the level of input self-sufficiency* (P2C2) at national level (e.g.: number of national feed suppliers; number of national hatcheries) and *the level of property rights over production site* (P2C5) at national level (e.g. duration of the lease; number of renewals of site leases per year) suggesting internal issues in the implementation process.



Key: case study 1 (Turkey), 2 (Tunisia), 3 (Montenegro) and 4 (Spain)

Social pillar

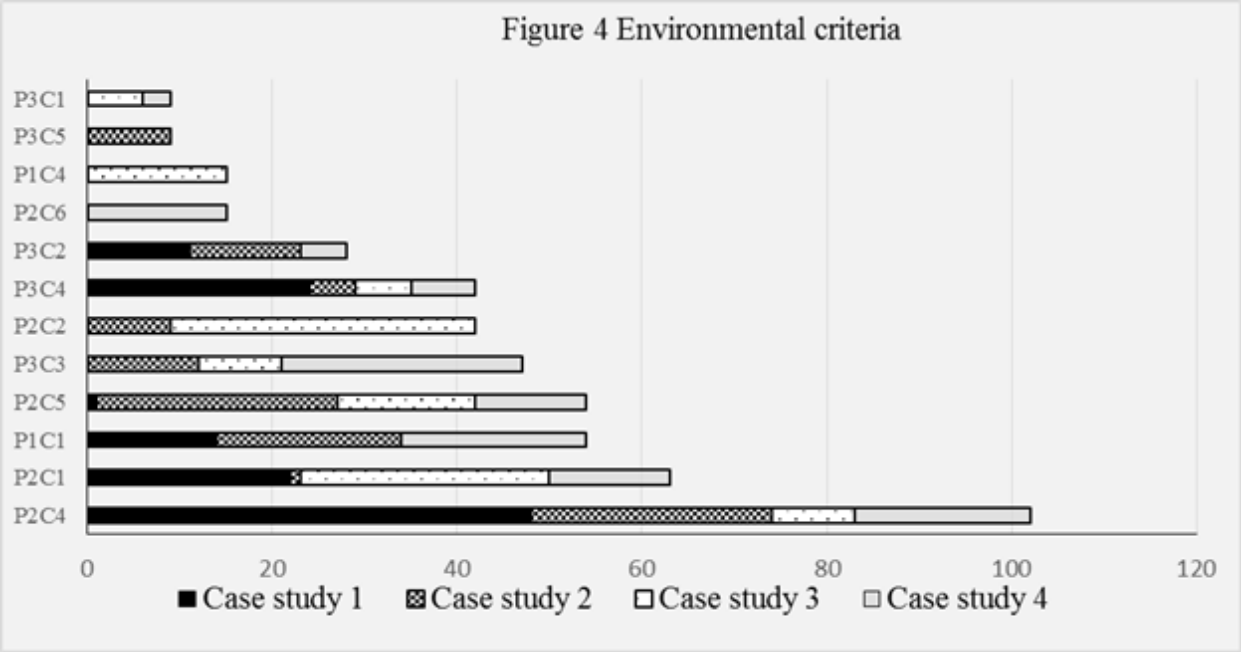
Regarding the social dimension (Figure 3), there is a general agreement over the criteria available and most of them (93%) were selected by at least three countries. In the Spain case study, the score was allocated evenly across 8 criteria. Overall, the most important criteria emerged as *the accessibility for local consumers* (P1C2) and *the importance of fish farmers organization* (P2C3) with *the working conditions (hours and security)* of employees (P3C1) coming in as the third most important. This implies that both producers and traditional consumers of fish are important in shaping the implementation of social criteria, as they represent a considerable part of the production chain. *Fish availability* (P1C1) and *fish welfare* (P3C5), the latter particularly in the Montenegro case study, also emerge as important criteria.



Key: case study 1 (Turkey), 2 (Tunisia), 3 (Montenegro) and 4 (Spain)

Environmental pillar

Results for the environmental pillar (Figure 4) are the most diverse amongst the case study countries in this analysis. *Oceanographic conditions* (P2C4), shared by all the four case studies, lead the ranking, with *water quality* (P2C1) ranked as important in only two of the country. The Turkey case study is most similar to the overall aggregated results but emphasizes *the impact on pelagic habitat and communities (*P3C4), whereas in the Tunisia case study the focus shifts to *the needs of natural resources (pelagic fish and vegetables) (*P1C1) and *trophic conditions* (P2C5). In the Spain case study, it was *the impact on benthic habitat and communities* (P3C3) that was prioritized.



Key: case study 1 (Turkey), 2 (Tunisia), 3 (Montenegro) and 4 (Spain)

Overall analysis

Out of the initial basket of 156 indicators selected at the regional level, 112 were chosen by local stakeholders, covering 54 of the 69 criteria available. Table 1 shows how many criteria (in percentage) were selected in the Governance, Environmental and Economic and Social pillars by different case study from the global initial basket of indicators, and the rate of indicators shared among the case studies for each pillar. Out of the four pillars, the Social pillar showed more commonalities: all the available criteria were represented and more than 90% were chosen by 3 or more countries, and more than half of them (53%) were selected by all the countries. Meanwhile for the Economic pillar, only 23% criteria were shared by all the case studies. Finally, for the Governance and the Environmental pillars there were for both 33% of the criteria shared.

Table 1. Criteria selected by pillar and the number of case studies

Pillar	Selected criteria / Total criteria	4/4	3/4	2/4	1/4
Social	17/23	53%	38%	7%	0%
Governance	12/14	33%	58%	0%	8%
Environment	13/13	33%	25%	8%	33%
Economic	12/19	23%	23%	23%	30%

The analysis performed showed some common elements in the four case study countries, highlighting their common priorities:

- *importance of research and training in aquaculture* (GOV-P3C1)
- *level of involvement of the state in the implementation of sustainable development (*GOV-P4C2)
- *capability to monitor and challenge pathological hazard (*ECO-P2C3)
- *use of branding or quality assurance schemes/labels* (ECO-P1C1) and *traceable products* (ECO-P1C2)
- *accessibility for local consumers* (SOC-P1C2)
- *importance of fish farmers organizations (*SOC-P2C3) and
- *oceanographic conditions* **(**ENV-P2C4).

Nevertheless, individual case study countries displayed specific priorities that reflect the nature and status of the aquaculture industry, the marine economy, natural resources and social needs at the time of the investigation.

The processes presented in this study confirm that in order to define priorities in aquaculture development, could be instrumental to bring together different actors and share discussion on the identification of indicators and criteria. The methodology applied, including the co-construction approach and the case studies for the identification of the indicators, proved to be also strategic in enhancing cooperation at the national and regional levels and in facilitating the process for the establishment of national and local aquaculture multi-stakeholder platforms. In many instances, it was the first time that representatives of farmers, administrations and research institutes had come together to improve the dialogue among parties and discuss aquaculture-related issues and priorities. The case studies resulted in an improved understanding and acceptability of indicators by local farmers, who, in some cases, had initially voiced their mistrust. This participatory process was instrumental in creating a common understanding and consensus among stakeholders on key concepts associated with aquaculture sustainability, consistent with the FAO CCRF, following an ecosystem approach to aquaculture (EAA) and within a blue growth perspective. This process also resulted in increased awareness and ownership among stakeholders and created an enabling environment and a framework for enhanced aquaculture governance in the region. An innovative use of these indicators was also developed on some occasions by adapting the proposed methodology to identify potential mariculture zones and to develop offshore farming based on sustainability indicators and AZAs. Communication tools were also considered essential to share sustainability concepts and contribute to raising awareness and enhancing public perceptions and the social acceptability of aquaculture among the public. The criteria and indicators identified during implementation of the different case studies were an important contribution to the preparation of the Strategy for the sustainable development of Mediterranean and Black Sea aquaculture adopted as Resolution GFCM/41/2017/1 at the forty-first session of the GFCM (Montenegro, October 2017) (FAO, 2018b).

5. Conclusions

Indicators represent a very important instrument to monitor various dimensions of sustainable aquaculture and to identify national priorities, especially when linked to higher-level criteria and generate consensus. They can help to shape future development and manage positive interactions between the economic, social and environment pillars of the aquaculture industry while minimizing negative ones (Caffey et al., 2001; Degnbol 2005; Ceriola et al., 2008; Valentin and Spangenberg, 2000; FAO, 2011; Valenti et al., 2011; Valenti et al, 2018, Fezzardi et al., 2013). Critically, they provide a roadmap for unpacking and making actionable what sustainable development means for aquaculture in the Mediterranean and beyond. In this article, it is highlighted that the selection of sustainable indicators in aquaculture, could also facilitate the identification process of priorities and action plans for sustainable aquaculture development at local level. In particular this can best be achieved if

relevant stakeholders are involved in a participatory co-construction process, where the process stimulates greater dialogue between them. A framework established in this way is more likely to lead to the adoption of aquaculture indicators by governments or local authorities and other decision-makers – and therefore to its sustainability.

Starting from common criteria in the long-term, the implementation of a system of indicators (number and level of use) may differ by country, by area, according to the level of maturity of the industry and to the principle of sustainability addressed. It may also differ according to evolving local, national and regional priorities. Thus, as the identification of indicators is a dynamic process that varies in space and time, it has reflected the status of aquaculture during the case studies period. That said, the four pillars of aquaculture sustainability will always need to address emerging issues and the indicators need to be regularly updated to reflect the latest scientific knowledge. In addition, the higher-level criteria on which they are based must also be kept under review as the implications of complex problems are better defined. In this regard it would be useful to continue working on the implementation of indicators, and also criteria, with a dynamic process of review, adjustment and periodic updates. This would enable the inclusion of indicators for new and emerging issues, which were not considered initially e.g. carbon dioxide (CO_2) dispersion in oceans causing acidification, climate change impacts on fish farming and vice versa, micro-plastics in seafood products, the influence of blue economic policy on the national context and the impact of the coronavirus pandemic in 2020.

Ultimately, the participatory development and use of specific aquaculture indicators and criteria can enhance the social acceptability of aquaculture activities, especially in those areas in which public perceptions hold back the development of the sector. Social acceptability of aquaculture and related "social license to operate" (SLO) are an essential part of aquaculture governance and in particular in the area where aquaculture needs to be implemented (Hishamunda et al., 2014). In this regard, the establishment of local aquaculture multi-stakeholder platforms, or other similar consultation platforms, could facilitate the co-construction process of setting-up a system of indicators, thus acting as a license to operate (LTO) enabling mechanism at the local level. Aquaculture indicators could be also used to follow the progresses made at the local, national as well as the regional scale within the framework of blue growth and a wide consensus in their application is a determining factor.

Expanding the number of case studies at the local level would also enable these criteria and indicators to be piloted for other contexts and promote their eventual uptake on a scale that is meaningful for sustainable aquaculture to become a reality.

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References

Barazi-Yeroulanos, L. 2010. 'Synthesis of Mediterranean marine finfish aquaculture – a marketing and promotion strategy. Studies and Reviews No 88, General Fisheries Commission for the Mediterranean, FAO, Rome**.**

Caffey, R.H., Kazmierczak, R.F. Jr & Avault, J.W. Jr. 2001. Developing consensus indicators of sustainability for Southeastern United States aquaculture. Louisiana State University Agricultural Center, Bulletin No. 879.

Ceriola, L., Accadia, P., Mannini, P., Massa, F., Milone, N. & Ungaro, N. 2008. A bio-economic indicators suite for the appraisal of

the demersal trawl fishery in the Southern Adriatic Sea (Central Mediterranean). Fisheries Research 92 (2008), 255–267.

Chia, E. 2010. Socio-territorial indicators. Role of the creation of social indicators in establishing sustainable development. In FOESA. Defining sustainability indicators for Mediterranean Aquaculture. Madrid, Spain, FOESA. 152 pp.

Chia, E., Rey-Valette, H. & Mathé, S. 2011. Aquaculture sustainable development and governance system (pp. 84-98). *In* GFCM, Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 2011: 218 pp.

Dalkey, N. & Helmer, O. 1963. "An Experimental Application of the Delphi Method to the use of experts". Management Science. 9 (3): 458–467.

Degnbol, P. 2005. Indicators as a mean of communicating knowledge. Ices Journal of Marine Science - ICES J MAR SCI. 62. 606-611.

European Commission. 2012a. CONSENSUS (Multi-stakeholder platform for sustainable aquaculture in Europe) - Final Report Summary. Available at https://cordis.europa.eu/result/rcn/51920_en.html (accessed in June 2018).

European Commission. 2012b. Blue Growth. Opportunities for marine and maritime sustainable growth. COM (2012) 494 final.

FAO. 1995. Code of the Conduct for Responsible Fisheries. Rome, FAO. 41 pp.

FAO. 1997. Aquaculture development. FAO Technical Guidelines for Responsible Fisheries. No. 5. Rome, FAO. 40 pp.

FAO. 1999. Indicators for sustainable development of marine capture fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 8. Rome, FAO. 68 pp.

FAO. 2010. Food and Agriculture Organization (FAO) (2010), 'Aquaculture development. Ecosystem approach to aquaculture', FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 4, Rome, FAO.

FAO. 2011. Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 2011: 218p. See Annex 2 for details.

FAO. 2012. Report of the thirty-sixth session of the General Fisheries Commission for the Mediterranean (GFCM). Marrakech, Morocco, 14–19 May 2012. GFCM Report. No. 36. Rome, Italy. 71 pp.

FAO. 2015. Achieving Blue Growth through implementation of the Code of Conduct for Responsible Fisheries.
Available at:
http://www.fao.org/fileadmin/user_upload/newsroom/docs/BlueGrowth_LR.pdf

FAO. 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome. 200 pp.

FAO. 2018. Report of the forty-first session of the General Fisheries Commission for the Mediterranean (GFCM), Budva, Montenegro, 16–20 October 2017. GFCM Report No. 41. Rome, Italy.

Fezzardi, D., Massa, F., Àvila-Zaragoza, P., Rad, F., Yücel-Gier, G., Deniz, H., Hadj Ali Salem, M., Hamza, H.A., Ben Salem, S. 2013. Indicators for sustainable aquaculture in Mediterranean and Black Sea countries. Guide for the use of indicators to monitor sustainable development of aquaculture. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 93. Rome, FAO 2013. 60 pp.

FOESA. 2010. Defining sustainability indicators for Mediterranean Aquaculture. FOESA, Madrid, Spain. 152 pp.

FOESA. 2011. Sustainability indicators for aquaculture sea cages in the Mediterranean. FOESA, Madrid, Spain. 116 pp.

Gabrielsen P., & Bosch P. 2003. Environmental indicators: typology and use in reporting. EEA, Copenhagen.

GFCM. 2012. Resolution GFCM/36/2012/1 on guidelines on allocated zones for aquaculture (AZA). Available at http://bit.ly/Resolution-GFCM-36-2012-1 (Accessed in June 2018).

Hishamunda, N., Ridler, N. & Martone, E. 2014. Policy and governance in aquaculture: lessons learned and way forward. FAO Fisheries and Aquaculture Technical Paper No. 577. Rome, FAO. 59 pp.

Madec, P. 2003. Les indicateurs de développement durable. INRA-University of Montpellier II. 118 pp.

Massa, F. 2011. Some key aspects related to the social dimension of aquaculture. *In* FOESA, Sustainability Indicators for Aquaculture Sea Cages in the Mediterranean, Madrid: FOESA, pp. 40–43.

Massa, F., Onofri, L. & Fezzardi, D. 2017. Aquaculture in the Mediterranean and the Black Sea: a Blue Growth perspective. *In* Handbook on the Economics and Management of Sustainable Oceans. Edited by Nunes P.A.L.D., Svensson, L.E. and Anil Markandya, A. Edward Elgar Publishing. 624 pp.

Mathé, S., Rey-Valette, H., & Chia, E. 2011. Key issue and some postulates concerning the use of indicators for sustainable development: the example of aquaculture (pp 75-83). *In* GFCM, Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 2011: 218 pp.

Mathé, S. & Rey-Valette, H. 2011. Towards the implementation of sustainable development of aquaculture in the Mediterranean: the conditions of governance. *In* GFCM, Indicators for the sustainable development of finfish Mediterranean aquaculture: highlights from the InDAM Project. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 90 Rome, FAO. 2011: 218 pp.

MFilm Montenegro. 2015. Sea Fishing and Mariculture in Montenegro YouTube. YouTube, LLC, 31 March 2015. Available at: https://www.youtube.com/watch?v=FMmFYBGStq8 (Accessed in June 2018).

OECD. 2003. OECD Environmental Indicators: Development, Measurement and Use. Reference Paper. Paris, OECD. 37 pp.

Pullin, R.S.V., Froese, R., Pauly, D. 2007. Indicators for the Sustainability of Aquaculture (pp 53-72). *In* Bert T.M. (eds) Ecological and Genetic Implications of Aquaculture Activities. Methods and Technologies in Fish Biology and Fisheries, Vol 6. Springer, Dordrecht.

Rey-Valette, H., Laloë, F & Le Fur, J., 2007. Introduction to the key issue concerning the use of sustainable development indicators. International Journal of Sustainable Development, 10: 4-13.

Rey-Valette, H., Clement, O., Aubin, J., Mathé, S., Chia, E., Legendre, M., Caruso, D., Mikolasek, O., Blancheton, J.P., Slembrouck, J., Baruthio, A., Rene, F., Levang, P. & Morissens, P. 2008. Guide to the co-construction of sustainable development indicators in aquaculture. EVAD project, Cirad, Montpellier (France), 144 pp.

Valenti, W., Kimpara, J. & L. Preto, B. 2011. Measuring Aquaculture Sustainability. World Aquaculture. 42. 26-30.

Valentin, A. & Spangenberg, J. 2000. A guide to community sustainability indicators. Environmental Impact Assessment Review. 20. 381-392.

Volpe, J.P., Beck, M., Ethier, V., Gee, J., & A. Wilson. 2010. Global Aquaculture Performance Index. University of Victoria, Victoria, British Columbia, Canada.