GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

ISSN 1020-9549

STUDIES AND REVIEWS

No. 93 2013

INDICATORS FOR SUSTAINABLE AQUACULTURE IN MEDITERRANEAN AND BLACK SEA COUNTRIES
Guide for the use of indicators to monitor sustainable development of aquaculture

Cover photos and design
Cover pictures: Gilthead seabream (*Sparus aurata*) in a floating cage, Italy, © FAO Aquaculture photo library / F. Cardia
Cover design by A. Nastasi

STUDIES AND REVIEWS **No. 93**

GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

INDICATORS FOR SUSTAINABLE AQUACULTURE IN MEDITERRANEAN AND BLACK SEA COUNTRIES

Guide for the use of indicators to monitor sustainable development of aquaculture

by

Davide Fezzardi, Fabio Massa, Pablo Àvila-Zaragoza, Ferit Rad, Güzel Yücel-Gier,

Hayri Deniz, Mohamed Hadj Ali Salem, Houssam Auadh Hamza, Skander Ben Salem

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2013

ISBN 978-92-5-107483-1

FAO information products are available on the FAO website (www.fao.org/publications) and can be purchased through publications-sales@fao.org.

PREPARATION OF THIS DOCUMENT

This publication provides guidance for the use of indicators to monitor the sustainable development of aquaculture in Mediterranean and Black Sea countries. It belongs to the GFCM Studies and Reviews series which includes scientific and methodological papers and deepenings on topics of interest for the General Fisheries Commission for the Mediterranean (GFCM) in the field of fisheries and aquaculture. This document mainly draws on the outcomes of the activities implemented within the project on “Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean” (InDAM project), funded by the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE), as well as on the outputs of other projects and initiatives dealing with Mediterranean aquaculture sustainability. InDAM has been carried out in support to the Working Group on Sustainability in Aquaculture (WGSA) of the GFCM Committee on Aquaculture (CAQ). The publication was prepared by the GFCM Secretariat in close collaboration with coordinators and experts of the WGSA, the Working Group on Marketing on Aquaculture (WGMA), the Working Group on Site Selection and Carrying Capacity (WGSC), the Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM), as well as with other experts involved in projects and research activities on indicators for sustainable aquaculture and key stakeholders.

ACKNOWLEDGEMENTS

The InDAM project was funded by the EU DG MARE. This publication is the result of a team work, and special gratitude is extended to the many experts, research institutes, non-governmental organizations (NGOs), national authorities and aquaculture farmers, for the pilot studies and for their cooperation with and contribution to the InDAM project. In particular, the following are acknowledged: the International Union for Conservation of Nature (IUCN), the Institut français de recherche pour l'exploitation de la mer (IFREMER), and the Faculty of Economic Sciences, University of Montpellier, France, for the I and II expert meetings; the Institut national des sciences et technologies de la mer (INSTM), Tunisia, for the first-year final meeting; the Ministry of Agriculture and Rural Affairs (MARA), Turkey, and the Provincial Directorate of Agriculture in Muğla, Turkey, for the pilot studies in Turkey; the Ministry of Agriculture of Tunisia for the first and second pilot studies in Tunisia, and the Institut national agronomique de Tunisie (INAT), Tunisia, for the second pilot study; the Centro Tecnológico de Acuicultura (CTAQUA), Spain, for the first pilot study in Spain; the Institut national de recherche halieutique (INRH), Morocco, for the first pilot study in Morocco; the Institut national de la recherche agronomique (INRA), France; the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), France; the Fundación Observatorio Español de Acuicultura (FOESA), Spain; the World Wild Fund for Nature (WWF), Flavio Corsin for his scientific advice on aquaculture certification; and Dominique Bourdenet, from the GFCM Secretariat, for the editing.

Fezzardi D., Massa F., Àvila-Zaragoza P., Rad F., Yücel-Gier G., Deniz H., Hadj Ali Salem M., Hamza H.A., Ben Salem S.
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.

ABSTRACT

Mediterranean and Black Sea aquaculture plays an important social and economic role in the GFCM region. The sustainability of the sector is increasingly challenged by old and emerging issues which require innovative measures to address the economic, social, environmental and governance aspects involved. An appropriate way of measuring and monitoring progress towards the sustainability of the sector is the use of indicators. This Guide on the application of indicators for sustainable aquaculture in Mediterranean and Black Sea countries attempts to meet the need for a decision support tool for monitoring the sustainable development of aquaculture in all its dimensions, based on a set of practical indicators and reference points. It draws elements from the literature, from the outputs of the “Indicators for Sustainable Development of Aquaculture and Guidelines for their Use in the Mediterranean” (InDAM project) carried out in support to the GFCM CAQ Working Group on Sustainability in Aquaculture (WGSA) and funded by the European Union, as well as from other recent regional initiatives. The Guide covers a wide range of topics related to aquaculture sustainability, including its general background, purpose, main target users and inspiring principles. After an introduction to aquaculture and to the main issues linked to the concept of sustainability and its dimensions from an aquaculture perspective, it presents the definition and use of indicators in aquaculture within a sustainability analysis framework and describes the participatory process to identify, select and use indicators as well as the methodology applied for assessing and displaying the values of indicators. This document also provides an overview of other uses of indicators within the aquaculture sector. Finally, it provides, for reference, a glossary of the main technical terms as well as a minimum set of regional indicators to assess and monitor the sustainable development of aquaculture in the GFCM area.

CONTENTS

1. INTRODUCTION 1
1.1 Background 1
1.2 Purpose of the Guide and application 4
2. MEDITERRANEAN AND BLACK SEA AQUACULTURE 6
2.1 Aquaculture methods and systems 6
2.2 Farmed species 7
2.3 Main challenges for the aquaculture sector 7
3. WHAT IS SUSTAINABILITY? 10
3.1 The dimensions of sustainability and the establishment of a system of indicators 11
3.2 Why sustainability? 14
4. INDICATORS FOR SUSTAINABLE AQUACULTURE 15
4.1 Definition and use of indicators in aquaculture 15
4.2 Indicators for assessing and monitoring aquaculture development 16
4.3 Level of applicability of indicators 20
4.4 Principles-criteria-indicators (PCI) approach 22
4.5 Presentation of indicators through methodology sheets 22
5. SELECTION AND USE OF SUSTAINABLE AQUACULTURE INDICATORS 27
5.1 General considerations on the process of selection of indicators 27
5.2 Step 1: Scope and objectives of indicators 28
5.3 Step 2: Pre-selection of indicators 30
5.4 Step 3: Indicators assessment and definition of quantitative reference framework 33
5.5 Step 4: Adoption and use of indicators 35
5.5.1 Indicators and traffic-light approach to display monitoring and assessment of aquaculture 36
5.5.2 The use of radar charts 38
5.6 Step 5: Evaluation of indicators and revision 38
6. OTHER USES OF INDICATORS 39
6.1 Codes of conduct, codes of practice and better management practices 40
6.2 Aquaculture legislation 41
6.3 Aquaculture certification 41
7. BIBLIOGRAPHIC REFERENCES 43
Appendix I. Glossary 50
Appendix II. Regional indicators for Mediterranean and Black Sea aquaculture 57

TABLES

Table I: Some definitions of “indicator” 16
Table II: Classification of indicators according to the types and main functions identified 19
Table III: Definition and level of applicability of indicators.... 21
Table IV: Indicators at different scales should be used by different bodies.... 35
Table V: Summary of examples of other uses of indicators in aquaculture 40

FIGURES

Figure 1. The dimensions of sustainability. 12
Figure 2. A framework for assessing and monitoring aquaculture development 17
Figure 3. The general process of selection and use of indicators 28
Figure 4. Example of radar chart 38

BOXES

Box A. InDAM key milestones towards the development of the Guide 3
Box B. Benchmarks considered by InDAM 18
Box C. The EVAD project and the co-construction approach 29
Box D. Using attributes to pre-select indicators: case studies in Turkey and Tunisia 31
Box E. Selection of indicators using the Delphi method: the Spanish pilot study 32
Box F. Assessment and final selection of indicators at local level: the InDAM pilot studies in Turkey and Tunisia 34

ABBREVIATIONS AND ACRONYMS

ASC	Aquaculture Stewardship Council
AZA	Allocated zone for aquaculture
BAP	Best aquaculture practice
BMP	Better management practice
B2B	Business to business
CAQ	Committee on Aquaculture
CCRF	Code of conduct for responsible fisheries
CoC	Code of conduct
CoP	Code of practice
CSR	Corporate social responsibility
DGPA	General Direction of Agricultural Production
EAA	Ecosystem approach to aquaculture
EQS	Environmental quality standards
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed conversion ratio
FEAP	Federation of European Aquaculture Producers
FOESA	Spanish Aquaculture Observatory Foundation
FSC	Forest Stewardship Council
GAA	Global Aquaculture Alliance
GDP	Gross domestic product
GFCM	General Fisheries Commission for the Mediterranean
GHG	Greenhouse gas
ICZM	Integrated coastal zone management
IDH	Sustainable Trade Initiative
IFREMER	Institut français de recherche pour l'exploitation de la mer
INRA	Institut national de la recherche agronomique
INRH	Institut national de recherche halieutique
INSTM	Institut des sciences et technologies de la mer
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LCA	Life cycle assessment
MARA	Ministry of Agriculture and Rural Affairs
MSC	Marine Stewardship Council
NACA	Network of Aquaculture Centres in Asia-Pacific
NGO	Non-governmental organization
PCI	Principles, criteria, indicators
SIPAM	Information System for the Promotion of Aquaculture in the Mediterranean
TLA	Traffic-light approach
UNCHE	United Nations Conference on the Human Environment
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCSD	United Nations Conference on Sustainable Development
WGSC	Working Group on Site Selection and Carrying Capacity
WGSA	Working Group on Sustainability in Aquaculture
WMS	Weighted mean score
WWF	World Wild Fund for Nature

1. INTRODUCTION

Aquaculture cages (Kimagro, Cyprus), photo ©FAO/Fabio Massa.

1.1 Background

Mediterranean and Black Sea aquaculture is a large and dynamic industry which has grown substantially in many GFCM countries over recent years and plays an important social and economic role in the region. Aquaculture provides opportunities to meet increased consumer demand for aquatic products while reducing the dependence on often over-exploited wild stocks. This sector, along its value chain, ensures job opportunities and contributes to food security in the whole GFCM area. The foreseeable future for the whole aquaculture production in the GFCM area still features a growing trend, although differences can be observed for some countries and species, showing great diversity in terms of technology, systems, production and markets. However, the sustainability of aquaculture in its economic, social, environmental dimensions and its overarching governance aspects call for short, medium and long-term measures to address the challenges the sector is currently facing.

Scant production, interaction of aquaculture with the environment and with other activities in coastal zones as well as the need for harmonized national legislations and timely provision of statistics on aquaculture, research and development issues, perception of aquaculture products, market competition from imported products and between Mediterranean and Black Sea countries, are among the most urgent constraints to be addressed to achieve better sustainability (GFCM, 2011c). The ultimate challenge is to create a conducive and enabling regional environment where aquaculture would continue to flourish in a shared market through modern governance, experience and knowledge sharing, and cooperation in the area.

The issue of sustainability for Mediterranean aquaculture has been the focus of recent projects, research and other initiatives which, broadly speaking looked, at the identification of indicators for sustainable aquaculture (GFCM, 2011c). The General Fisheries Commission for the Mediterranean (GFCM), has identified the development of sustainable aquaculture in the Mediterranean and Black Sea as a priority, and its Committee on Aquaculture (CAQ) has embarked since 2003 in a series of consultative meetings and workshops. This process was instrumental in raising awareness about this issue and eventually led to the formulation of the four-year European Union (EU) funded project "Indicators for Sustainable Development of Aquaculture and Guidelines for their Use in the Mediterranean (InDAM), which was designed and developed within the Working Group on Sustainability in Aquaculture (WGSA) of the GFCM-CAQ.

InDAM addresses sustainability issues for finfish marine aquaculture in the GFCM region and, through a multi-stakeholder, participatory and multi-disciplinary methodology, aims at providing countries with a comprehensive decision-support tool for the sustainable development of aquaculture in its economic, social, environmental dimensions and governance. This tool is based on a set of practical indicators, reference points and standards, and on a guide adapted to the Mediterranean and Black Sea. An additional objective of InDAM is to support the establishment of a regional reference system for the development of sustainable marine aquaculture in the Mediterranean Sea, by integrating the economic, social, environmental dimensions and overarching governance into the concept of integrated coastal zone management (ICZM) and by using the ecosystem approach to aquaculture (EAA)[1] in the selection of indicators.

More specifically, this guide (hereafter referred to as "the Guide") provides indications on the application of indicators for sustainable aquaculture in Mediterranean and Black Sea countries. It stems from a highly participatory consultative process which started in November 2008, involving a wide range of experts in a multi-disciplinary way, to ensure robustness, balance of opinion and ownership of all concerned regional stakeholders.

The Guide also takes into consideration the results of other GFCM projects, including the GFCM-CAQ SHoCMed[2] and the MedAquaMarket[3] projects and builds on works carried out on indicators (FAO, 1999; Bondad-Reantaso and Prein, 2009). It also draws upon relevant experiences in the Mediterranean, based on a participatory process and focused on sustainable aquaculture such as EVAD[4] (Rey-Valette *et al.*, 2008), the Federation of European Aquaculture Producers (FEAP), the Code of Conduct for European Aquaculture (FEAP, 2006), the Guidelines of the Spanish Aquaculture Observatory Foundation (FOESA) (FOESA, 2010), and the Guidelines of the International Union for Conservation of Nature (IUCN) (IUCN, 2007, 2009a and 2009b).

---

[1] An ecosystem approach to aquaculture is a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems (FAO, 2010a).

[2] The GFCM project "Developing site selection and carrying capacity for Mediterranean aquaculture within aquaculture appropriate areas" (SHoCMed) is funded with the contribution of the EU DG MARE.

[3] The GFCM project "Development of a Strategy for Marketing and Promotion of Mediterranean Aquaculture" (MedAquaMarket) is funded with the contribution of the Spanish Government (Secretaria General de Pesca, Ministerio de Agricultura, Pesca y Alimentación).

[4] EVAD was a research programme focusing on methodological questions regarding the evaluation of aquaculture sustainability. It aimed at developing a tool to evaluate sustainability based on indicators and taking into account shared aquaculture issues as well as local specificities related to the territorial dimension (environmental, economic, social and governance context) of aquaculture.

Box A
InDAM key milestones towards the development of the Guide

Bottom of a floating cage, Italy, photo ©FAO Aquaculture photo library/Francesco Cardia.

- Consensus definition of and guidance towards aquaculture sustainability in the Mediterranean region consistent with an ecosystem approach to aquaculture;

- Overall methodology identification and adoption: principles-criteria-indicators (PCI) approach and co-construction process, and use of a common understanding on the terminology adopted at regional level (Montpellier, France, November 2008);

- Identification of a preliminary pool of 156 indicators covering the dimensions of sustainability: economic, social, environmental and governance;

- Methodology identification to carry out pilot studies including the use of attibutes to prioritize and select indicators (Montpellier, France, February 2009);

- Prioritization of indicators at local and national level and methodological approach for their applicability to marine finfish aquaculture through four pilot studies in Turkey, Tunisia, Spain and Morocco (June 2009–October 2011);

- Identification of guide methodology (Tunis, Tunisia, December 2009);

- Definition of the geografical scales of indicators and consensus on the selection of a minimum set of indicators for the Mediterranean region (Malta, 2010; Malaga, Spain, 2011);

- Guide preparation (July 2011–February 2013).

The Guide is divided into six main parts:

- **Part 1** describes the general background, purpose, main target users and inspiring principles of the Guide.
- **Part 2** briefly introduces Mediterranean marine aquaculture highlighting its features and main issues.
- **Part 3** addresses the concept of sustainability and its dimensions from an aquaculture perspective.
- **Part 4** provides a definition of an indicator and its related attributes.
- **Part 5** discusses the selection and use of indicators together with the methodology for assessing indicators.
- **Part 6** looks at other uses of indicators within the aquaculture sector.

Finally, a glossary of the main technical terms used in the Guide and a minimum set of regional indicators to assess and monitor the sustainable development of aquaculture in the GFCM area are provided in appendix.

The Guide promotes responsible and sustainable aquaculture at production level, in line with the FAO Code of Conduct for Responsible Fisheries (CCRF), in particular its article 9 on aquaculture development (FAO, 1995), the FAO Technical Guidelines for Responsible Fisheries on Aquaculture Development, including its supplements, the ecosystem approach to aquaculture (EAA) (FAO, 1997; FAO, 2010a) and other international instruments.

1.2 Purpose of the Guide and application

The Guide is a new voluntary instrument to provide directions on the use of indicators for sustainable aquaculture in the Mediterranean and Black Sea. It tackles a wide range of issues that are considered relevant when identifying and selecting sustainability indicators, namely to monitor progress towards sustainability and the implementation of development policies. Given the fast evolving principles related to sustainable development, this document should be considered as a dynamic tool which can be adjusted over time.

Focusing on the needs of Mediterranean and Black Sea countries, local solutions are proposed, when required by specific circumstances, in order to account for the diversities in the GFCM region and ensure a good adaptation of indicators to the field and needs. The contents of this book are based on the experiences and lessons learnt from several initiatives, including the pilot studies implemented within the InDAM project, and draw upon the efforts carried out in finfish marine cage aquaculture.

This tool would need to be interpreted and applied in its entirety, consistently with national laws and regulations and, where they exist, international agreements. However, when national legislation is inconsistent with the orientations set forth, it may provide guidance for amendments, inspire new legislative provisions and help supplement customary norms and regulations.

The aim is to establish a set of principles and criteria and provide recommendations on how to achieve sustainable development. More specifically, the intent is to:

- Suggest a comprehensive framework to improve the understanding of actions needed to support aquaculture development and governance in the Mediterranean and the Black Sea;
- Establish principles, criteria, indicators (PCI) and, when applicable, provide standards and reference points at a local, national and regional level;
- Serve as a reference tool to be used at different scales;
- Facilitate cooperation among all stakeholders directly or indirectly involved in aquaculture and enhance communication between farmers and society at large;
- Promote further research on the development and use of sustainability indicators.

The Guide is both inspirational and practical. This is why it has to be anchored in the day-to-day reality of aquaculture farmers' communities while opening a long-term perspective with a view to ensuring the sustainability of aquatic-based livelihoods and the environment they depend on.

As a tool at the disposal of Mediterranean and Black Sea countries, it could be used by decision-makers from regional, national and local administrations, governmental and non-governmental organizations (NGOs), research and academic institutions, the private sector, aquaculture producers and fishing communities, and all other stakeholders concerned with the aquaculture sector, coastal development and the use of the aquatic environment.

2. MEDITERRANEAN AND BLACK SEA AQUACULTURE

Aquaculture cages, photo ©FAO/Fabio Massa.

Endowed with favourable geographical conditions and ideal growth parameters, modern Mediterranean and Black Sea aquaculture industry has been flourishing, especially in the last four decades. The global trend has been positive in the GFCM competence area, with particular respect to coastal and marine aquaculture.

2.1 Aquaculture methods and systems

Mediterranean and Black Sea aquaculture encompasses a large variety of technologies and production systems which are used in different environments and can be applied in fresh, brackish and marine water. Aquaculture can be broadly and traditionally classified according to three different methods of culture based on production intensity, namely: (i) extensive culture (the cultured stock obtains all the nutrition required from the natural food produced in the containment where it is reared and/or through the water supplied to the containment) which includes for example inland plants, ponds and valliculture in coastal lagoons; (ii) semi-intensive culture (the cultured stock is provided a part of the nutrition required externally, mostly through supplementary feeding) which includes for instance inland plants in dams, ponds and estuarine areas; and (iii) intensive culture (all the nutrition that the culture stock requires is provided externally) which comprises *inter alia* inland raceways, cages in inland lakes and reservoirs, and offshore cages at sea (GFCM, 2009b).

2.2 Farmed species

Marine and brackish water aquaculture in the GFCM area is mainly dominated by the production of fish and molluscs, generally with focus on high value species. Marine fish is the group that has grown steadily over the last 20 years, with a production largely accounted by two key species, namely the European seabass (*Dicentrarchus labrax*) and the gilthead seabream (*Sparus aurata*).

In particular, for marine and brackish water aquaculture, producing countries in the region are now at a different stage of industry maturity which depends on multidimensional factors, and could be grouped based on their volume of production (Barazi-Yeroulanos, 2010).

Within the GFCM area of competence and taking into consideration only species farmed in brackish and marine water, six countries emerge as main producers in the whole Mediterranean and Black Sea region: Turkey is the major producer of European seabass (*Dicentrarchus labrax*), Greece dominates the production of gilthead seabream (*Sparus aurata*) in the Mediterranean, while Egypt is the main producer of mullets (*Mugilidae spp*); and regarding molluscs, Spain is the main producer of Mediterranean mussels (*Mytilus galloprovincialis*), France of Pacific cupped oyster (*Crassostrea gigas*), and Italy of Japanese carpet shell (*Ruditapes philippinarum*) (Barazi-Yeroulanos, 2010; GFCM, 2011d).

2.3 Main challenges for the aquaculture sector

Despite its undoubted success, the coastal and marine aquaculture industry has faced cycles of alternate positive and negative phases, going from high margins-low volumes to low margins-high volumes, and it is currently looking at the development of new species for production in order to offer a wider range of products to customers; however, to date most of these species are still in the experimental or pilot stage (Barazi-Yeroulanos, 2010). This expansion, however, has been raising several country-specific concerns encompassing economic, environmental and social aspects, which could put at stake the sustainability of the sector. In this regard and bearing in mind specific differences reflecting cultural, social, economic and legislative aspects which are peculiar to each Mediterranean region, the following major issues have been identified and urged to be properly addressed in order to respond effectively to the sustainability challenge of the Mediterranean and Black Sea marine aquaculture (Barazi-Yeroulanos, 2010; GFCM, 2011d):

Acceptability of aquaculture products

In many areas, marine aquaculture is still perceived negatively, especially in connection to its possible impact on the environment. Additional concerns also include food quality and safety, social integrity, certification and traceability, and organic aquaculture. As a matter of fact, the aquaculture industry has achieved important goals connected to those aspects but nevertheless, information, divulgation and the transfer of aquaculture knowledge to society in general is a pending issue.

Animal welfare

Marine aquaculture is prone to pathologies which can jeopardize the production and thus its sustainability. Healthy fish, thanks to a good health management system, appropriate use of veterinary medicines and chemicals, use of risk assessment as management tools for disease prevention, all translates into fewer consequences (such as antibiotic resistance and reduced food safety and quality) for the environment and human health.

Capture fisheries – aquaculture interactions

In the Mediterranean, aquaculture and capture fisheries have been coexisting for centuries, with the complementary objective of ensuring the availability of aquatic organisms for direct or indirect human consumption. From a sustainable development perspective, monitoring the interactions between capture fisheries and aquaculture within marine and coastal ecosystems is quite relevant to understand their mutual benefits and potential conflicts in the context of the FAO CCRF and of ICZM.

Certification

Consumer awareness of environmental integrity, food quality and safety of aquaculture products increasingly tends to become a precondition for the acceptability and growing consumption of Mediterranean products. Quality issues, certification and traceability of aquaculture products are prerequisites to improve the image and public perception of farmed products. Concomitantly, support to the development of biological and organic aquaculture represents an additional opportunity for the Mediterranean market.

Climate change

Although the phenomenon of climate change and climate variability has been known for centuries, it is only in recent years that the scenarios proposed by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007) raised concerns regarding possible impacts, especially on freshwater, coastal and marine ecosystems which sustain the fisheries and aquaculture sector. Climate change will broadly impact across ecosystems, societies and economies and can be considered as a compounding threat to the sustainability of Mediterranean and Black Sea aquaculture development. Key issues related to the effects of environmental conditions on the growth performance of farmed species and their repercussions on economic performance and social aspects should be taken into proper consideration in a changing climate.

Conflicts over use of coastal areas

The interactions of aquaculture with other activities such as coastal zone fisheries, tourism, transport and navigation, to name but a few, can generate competition with other users of the concerned coastal zone. ICZM could be considered as a viable framework for a better marine spatial planning and aquaculture zoning site selection, also within an ecosystem perspective, and through the establishment of allocated zone for aquaculture (AZA) in order to minimize current conflicts over space use. Participatory approaches should be followed through the involvement of local communities during planning activities.

Environment – aquaculture interactions

The effects of aquaculture activity on the environment and vice versa have been widely proved (IUCN, 2007). Understanding their interactions, including aspects related to carrying capacity, impacts on sensitive habitats, assessment of monitoring procedures and harmonization of regulatory procedures, is therefore of paramount importance to minimize environmental impacts.

Information management

A timely provision of data and statistics on marine aquaculture is needed in order to be able to assess and monitor aquaculture production and production capacity. Market data should also be available to monitor the marketing of aquaculture products. Strategic market data such as levels of fish consumption, distribution channels, market trends and trade information on aquaculture products should be made available to farmers, policy-makers and other key stakeholders.

Legal framework and procedural aspects

In the whole GFCM area, there is a generally heterogeneous legal framework pertaining to aquaculture, which calls for harmonization and simplification of policies. Policies should be more comprehensive and encompass production systems and other relevant aspects pertaining to sustainable aquaculture development, in order to enable better coordination and synergies among competent authorities.

Promotion and marketing

Market competition of aquaculture products from the GFCM area occurs both among member countries and with imported products from other world areas. A proper sector marketing strategy is deemed necessary to address price stability and the exploitation of existing and emerging niche markets. This could be pursued, in particular, through an effective promotion and marketing communication strategy and by fostering certification and labelling systems to respond to an increasing demand and willingness to pay for products from sustainable aquaculture. The introduction and enforcement of traceability systems and the development of added value and processed products should also be considered. Aquaculture farmers' organizations could play a crucial role in supporting any of such marketing strategies.

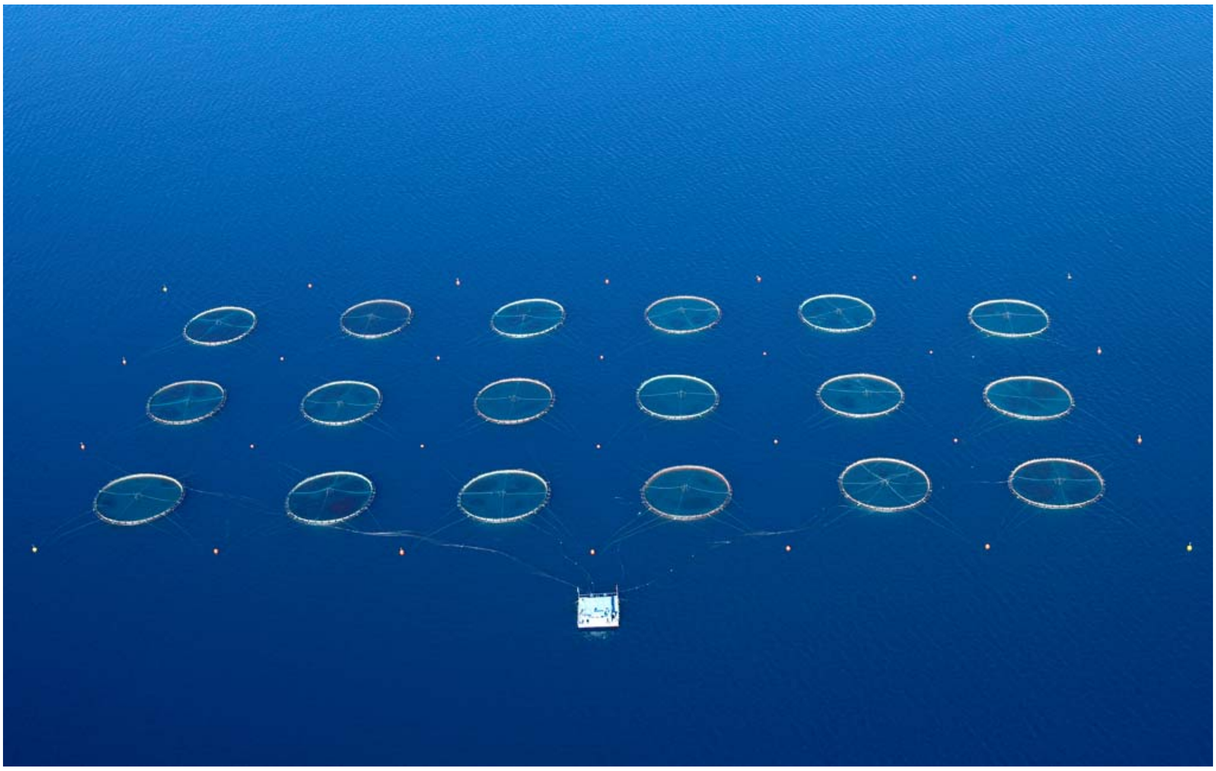
Scientific research and cooperation

For a more sustainable and competitive sector, there is a need to foster scientific research on species and new models to diversify production towards new market opportunities. Enhanced cooperation and coordination, knowledge and data sharing among specialized research bodies as well as national capacity-building would be crucial for a more responsive industry.

Challenges linked to aquaculture are generally of a cumulative and additive nature. "Cumulative" means that although some of the problems may be addressed and solved at the individual farm level, most are cumulative so that the impact might be insignificant when an individual farm is considered, but could be potentially highly significant in relation to the whole aquaculture sector. "Additive" implies that the impact of aquaculture may add to the many other pressures and impacts of development in the marine coastal zone (GESAMP, 2001).

In an increasingly densely populated coastal area where multiple activities are intertwined, putting an overly pressure on the environment and marine ecosystems striving to achieve sustainable development is a considerable endeavour which calls for sometimes difficult societal choices, for the adoption of specific decision-making schemes, and for better and integrated planning and management of the sector. In particular, the development of sustainable aquaculture in the Mediterranean and Black Sea requires, first of all, a common understanding of sustainability concepts, especially with respect to marine aquaculture and its governance.

3. WHAT IS SUSTAINABILITY?



Aquaculture cages (Turkey), photo ©Hayri Deniz.

Many issues could arise from this simple question. Sustainability is a complex concept which encompasses many aspects, including interdisciplinary dialogue, interaction and research.

The idea of sustainable development first arose at the landmark United Nations Conference on the Human Environment (UNCHE) held in Stockholm, Sweden, in 1972. The concepts of resource development and utilization emerged as ones that are and must be closely linked to the issues of conservation (FAO, 2005–2012).

Since aquaculture as an economic activity is strictly linked and directly depends on the quality of the environment (Pillay, 1990), all efforts and interests should be directed towards the preservation of the environment to assure the permanence of the activity in the long term. In this respect, at the United Nations Convention on the Law of the Sea (UNCLOS), in 1982, not only the issue of protecting marine ecosystems from damaging activities and harm, but also the matter of exploitation which would contribute to sustainable development were addressed (FAO, 2005–2012).

Development, conservation, rational management and best utilization of living marine resources as well as sustainable development of aquaculture all involve many issues connected to the environment at a larger scale, that is the social and economic dimensions and how it is managed through governance.

Sustainability, which is the capacity to persist in the long term, to endure, is sometimes used as synonymous of sustainable development. The classic definition of sustainable development proposed by the Brundtland Report in 1987, which simply and briefly defined sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" has undergone many re-interpretations to understand

and operationalize the elusive subject of sustainable development (Espaldon, 2009). For the practical purpose of this Guide and in relation to agriculture, forestry and fisheries, the following definition of sustainable development (FAO, 1997) is adopted:

> *"*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*"*.

At the 1992 Earth Summit in Rio de Janeiro, the international community adopted the Agenda 21, an unprecedented global plan of action for sustainable development. Agenda 21 introduced the concepts of "pillars of sustainability", also called "dimensions of sustainability", by integrating environmental, economic and social concerns into a single policy framework. The 2002 World Summit on Sustainable Development in Johannesburg reaffirmed that sustainable development was built on three interdependent and mutually reinforcing pillars which must be established at local, national, regional and global levels. The summit also introduced the importance of governance as an overarching dimension of sustainability, stressing the need to build strategic partnerships and collaborations between governments, the private sector (public-private partnerships), civil society and international agencies, all acting together to reach sustainability.

In the light of the United Nations Conference on Sustainable Development (UNCSD or Rio+20) held in Rio de Janeiro in 2012, which builds upon the outcomes of previous UN conferences focussing on sustainable development, the concept of "green economy" has been put forward in the context of sustainable development and poverty eradication.

This Guide is based on a common definition and framework of sustainable development of Mediterranean and Black Sea aquaculture which relies on its pillars and their integration. Ensuring that aquaculture is undertaken sustainably lies at the heart of the 1995 FAO CCRF, and sustainability of Mediterranean and Black Sea aquaculture has been one of the main items on the agenda of GFCM members since the technical consultations held in FAO (Rome, 1999), where the application of the principles set forth in article 9 of the CCRF was discussed and pertinent priorities for the development of sustainable aquaculture in the GFCM area were agreed upon. The Guide also builds on the works carried out by FAO on indicators for sustainable development (FAO, 1999) in support to the implementation of the CCRF.

3.1 The dimensions of sustainability and the establishment of a system of indicators

In this context and within the Mediterranean and Black Sea area, discussions over the development and establishment of a system of indicators to assess and monitor the contribution of aquaculture to sustainable development have been going on for years. The aim of the system of indicators is to monitor progress in the development of sustainable aquaculture and it is intended as a tool to establish a common language in the GFCM area that could provide a basis for enhanced commitment towards economic, social, environmental and good governance goals. To discuss sustainability and articulate discussions according to its different dimensions – which represent the main areas of interest as far as sustainability is concerned – these concepts should be introduced. Nevertheless, and given the strictly intertwined relationships among the different dimensions, it might be sometimes difficult to establish clear boundaries between definitions, which necessarily overlap to some extent (Fig. 1).

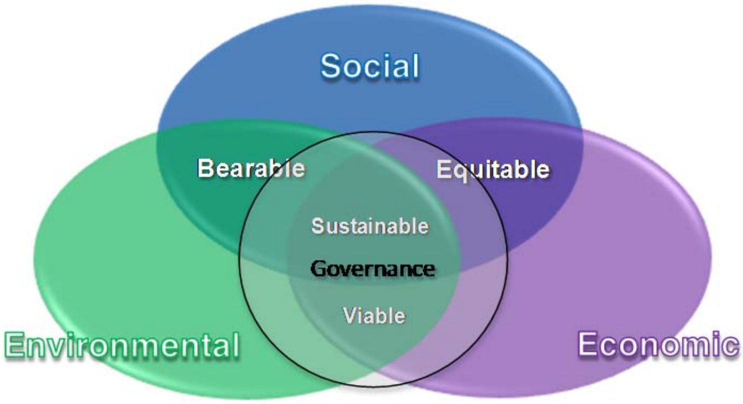


Figure 1. The dimensions of sustainability

The economic dimension

The sustainable development of aquaculture calls for its economic viability. Aquaculture is first and foremost a business undertaken by farms, which are profit-making entities that compete in domestic and international markets for their financial sustainability. However, sustainability requires striking a balance between financial profitability and respect of the environment where companies operate: reducing aquaculture negative externalities, such as the impact on ecosystems and the services they provide, translate into decoupling environmental degradation and economic growth. An economically viable and sustainable aquaculture sector requires that aquaculture operations are financially well managed and performed; therefore, strengthening both the financial management of enterprises, so to ensure economic efficiency on a medium-long term, and risk assessment as well as crisis management capacity is of paramount importance. From a social perspective, aquaculture plays a strategic economic role at local level, by providing job opportunities and creating complementary activities which are geared around the sector. At the national level, aquaculture, as an economic sector, contributes to the country gross domestic product (GDP). In a market economy, aquaculture is subject to market crisis as well as negative externalities, which must be mediated through good governance.

The social dimension

Sustainable development of aquaculture calls for its social acceptability. Broadly speaking, social sustainability bears the concept of inter and intra-generational equity. The former states that current and future generation should have the same access to social resources; whilst the latter emphasizes that there should also be equal access to the same resources within the current generation. Within the fisheries and aquaculture sector, the CCRF stresses the key role of the social dimension through a series of provisions aiming at supporting the elaboration of national policies for responsible development of aquaculture (FAO, 1995). The social dimension of aquaculture within the GFCM area encompasses many interlinked aspects at every level where stakeholders operate, with differences among countries which reflect specific cultural aspects of the Mediterranean and Black Sea region. At farm level, social responsibility tackles internal and external business aspects and is related, *inter alia*, to factors such as equity, fairness, transparency and accountability. Internal aspects include sound and fair treatment of employees according to national regulations and labour laws, safety at work, health and hygiene, and welfare. On the other hand, good relationships with the surrounding communities, government agencies, traders and customers, NGOs as well as other key players are all connected with social accountability towards external stakeholders. Within the social acceptability component, great attention should be paid to the community in particular and to stakeholders' participation in general during the planning phase of aquaculture development, in order to minimize potentially negative impacts and improve the public image of aquaculture. In this context, a special role could be played by aquaculture farmers' organizations in promoting sustainable aquaculture. Aquaculture also means job possibilities which would be crucial in those GFCM members where opportunities for employment could have a positive effect on reducing migration, contemporaneously contributing to reinforce social stability.

The environmental dimension

The sustainable development of aquaculture calls for a sound relationship with the environment. Environmental pressures and impacts of human activities on the Mediterranean and the Black Sea are likely to be exacerbated in the foreseeable future by many factors, including marine traffic (roughly 1/3 of global marine traffic occurs within the GFCM area) and urbanization (half of the coastline of the Mediterranean Sea has become artificial). Impacts from other human activities on the environment surrounding aquaculture farms can have a negative influence on aquaculture itself and should also be accounted for within the environmental dimension. Furthermore, the traditional lack of sectoral integration (i.e. planning and implementation) has often led to competition and conflicts over marine spaces and uses among the different subjects involved within the relevant coastal zone. In this context, aquaculture has traditionally been associated with pollution, environmental impact on sensitive habitats, coastal erosion and loss of biodiversity, which has inevitably contributed to build a negative image of this industry worldwide. Aquaculture may affect environmental quality and the interests of other users as a result of its impacts and may itself be seriously affected by water quality and habitat degradation caused by other human activities. Although it is inevitable that, as any other industry, aquaculture will have an impact on the environment, the surrounding environment impacts on aquaculture just as at the same time; therefore, there is a need to clearly define the level of environmental acceptable change and risks associated to doing aquaculture.

Poorly sited or planned aquaculture may result in negative feedback, bad public image of its impact on the environment and self-pollution. The introduction of allocated zones for aquaculture (AZA) – i.e. marine areas where the development of aquaculture is prior to other uses – would be instrumental in avoiding some impacts of aquaculture by improving the site selection process and, in turn, protecting aquaculture itself from adverse environmental conditions. This would also likely prevent conflicts among stakeholders on the use of the marine resources by enhancing the integration of aquaculture with other activities within the coastal areas.

In Mediterranean countries, the adoption of a harmonized monitoring system to evaluate the effects and possible impacts of aquaculture on the environment is essential to prevent any negative effect without irreversibly compromising basic environmental services provided by the ecosystem. Such monitoring system should be simple, efficient, cost-effective and based on commonly agreed environmental quality standards (EQS) as descriptors of environmental change.

Finally and as far as climate change is concerned, it is commonly acknowledged that the root cause of climate change is linked to carbon emissions, namely greenhouse gas (GHG). Although aquaculture makes a minor – but still significant – contribution to GHG emissions throughout the sectors' supply chain, studies carried out using life cycle assessment (LCA) show that most of aquaculture activities feature carbon emission values (carbon footprint) that are lower than those of other farm-raised protein industries such as livestock.

Aquaculture governance: an overarching approach

An integrated and holistic approach to aquaculture should also be based on an overarching strategy where good governance in aquaculture would establish overriding principles and objectives for the sustainable development of the sector. In the fisheries sector as a whole, the concept of governance has gained increasing significance in development approaches, in recognition that formal and informal institutions need to be carefully understood and selectively supported or promoted if positive development objectives are to be realized. Good governance mainly derives from national and local policies which take into consideration the sustainable development of the sector (FAO, 2008–2012).

3.2 Why sustainability?

The expansion of the aquaculture sector has brought about a series of environmental, social and economic concerns which impact on the sustainability of the sector and require the setting up of a series of principles and standards in order to enable marine aquaculture to be well positioned in terms of development.

The development of sustainable aquaculture is requested by the civil society as an essential process which concerns all public policies and which is becoming increasingly assimilated as a concept by all relevant stakeholders (Mathè *et al*., 2011). Setting up a common understanding of sustainability in aquaculture among the different actors would improve communication and make the process towards the sustainability of aquaculture itself more effective. Awareness-raising and ownership by stakeholders are instrumental in creating and facilitating conditions for the implementation of an efficient decision-making process and of regulatory systems where the management and conservation of natural resources and human well-being would be considered as a reference framework towards effective governance.

Over the last decade, efforts have been made towards addressing the sustainability challenges of aquaculture. To reduce their vulnerability and increase their corporate social responsibility (CSR) image, several retailers, brands, seafood buyers, etc. have started cooperating with agencies working in the sector to develop, for example, seafood purchasing policies or support certification schemes that are recognized as credible. In this case, addressing sustainability can not only translate into reduced vulnerability of a producer or value chain, but also improve market access and, in some cases, bring profits, for example through premium prices.

Economic sustainability is always desirable and, arguably, the primary target of producers. However, it is closely related to other aspects of sustainability. For example, environmental sustainability (which is often based on preserving ecosystem services in the area where a farm operates) and the lack of it (for example pollution) can affect negatively farming outputs. Similarly, failing to address social sustainability, for example disregarding employees' needs, may result in poorer efficiency. Understanding local communities' needs and addressing them in an open manner can bring a balance that reduces the risk of conflicts, hence increasing chances of success. Sustainability issues will also be targeted by producers if included in the legislation. Regulating farms locations, water quality or conditions of employment are typical examples where governments address sustainability issues through legislation.

4. INDICATORS FOR SUSTAINABLE AQUACULTURE

Feeding fish in submergible cages, Italy, photo ©FAO Aquaculture photo library/Francesco Cardia.

4.1 Definition and use of indicators in aquaculture

Since the 1992 Rio Conference, monitoring and measuring sustainability has been a compelled task aimed at informing policy-makers throughout the process of sustainability governance. The most common way of measuring sustainability through its various dimensions is the use of indicators, which can provide information on any aspect linked to the interplay between the economic, social and environment facets of a sector or activity.

There are many definitions of an indicator and some of them are reported in Table I. The three basic functions of an indicator are: simplification, quantification, and communication, and good characteristics include being measurable and achievable. According to Gabrielsen and Bosch (2003), an indicator is an observed value which is representative of a phenomenon studied. Indicators quantify information by aggregating different and multiple data, the resulting information being therefore synthesized. Indicators thus simplify information that can help reveal complex phenomena.

Generally speaking, an indicator is a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions in a given dimension.

When evaluated at regular intervals, an indicator can point out the direction of change across different units and through time. Indicators are useful to identify trends and draw attention to particular issues, and they can also be helpful in setting policy priorities and benchmarking or monitoring performance (OECD, 2008).

Table I: Some definitions of “indicator”

Definition of “indicator”	Source
An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria.	*FAO, 1999*
Indicators are tools for monitoring, evaluation, forecasting and decision support. They are defined by reference to agreed targets; the confrontation of values taken by an indicator with the corresponding objective allows judging the effectiveness of an action. Indicators are also communication tools that are used to quantify and simplify information to make it understandable to a targeted audience.	*Madec, 2003*
Indicator is a parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value.	*OECD, 2003*
An indicator is an observable variable used to report a non-observable reality.	*Boulanger, 2004*
Indicators are not just tools for measuring progress or a specific situation. They are also inventories which enable a variable to be defined, amongst several others. The variables can be arranged in order of importance to form a sort of control panel. But an indicator is also an internal and external communication vector. The indicator becomes a standard once it is accepted and its limitations are identified. It becomes the signal which can eventually entail penalties for situations which, beyond the aforementioned threshold, are considered negative.	*Chia, 2010*

Within the fisheries sector, indicators can provide a readily understood instrument for describing the state of aquaculture and resources and for assessing trends towards sustainable development objectives (FAO, 1999). Indicators can efficiently and effectively communicate complex scientific concepts and results, and support decision-making and policy-setting at every stage of the decision-making cycle, including problem identification, policy formulation, implementation and/or policy evaluation (FAO, 1999). The application and the use of indicators for sustainable aquaculture are considered as the most appropriate tool to create the conditions for sustainable growth and necessary to assess and monitor progress of aquaculture activities (GFCM, 2011c).

4.2 Indicators for assessing and monitoring aquaculture development

Indicators are only useful if the objectives for measuring them are clear. Indicators should be able to answer basic questions. Descriptive indicators would provide answers to queries such as “What is happening in the aquaculture sector?”. On the other hand, performance indicators would clarify whether set targets are being achieved, while efficiency indicators would show if there has been any improvement. The Guide is based on a common definition and framework for the sustainable development of Mediterranean and Black Sea aquaculture: sustainability dimensions – environment, economic, social and overarching governance – provide the basis from which indicators are selected.

However, as far as sustainability analysis is concerned, it would also be useful to classify indicators according to their position and contribution to the aquaculture sustainability approach. Moreover, it would be necessary to provide a framework (Fig. 2) representing the functional typology of the levels of interaction and positions of indicators with relation to the aquaculture sustainability analysis (Mathé *et al*., 2011a). A framework helps identify and organize the issues that will define what to measure, what to expect from measurement and what kind of indicators to use (Pinter *et al*., 2005).

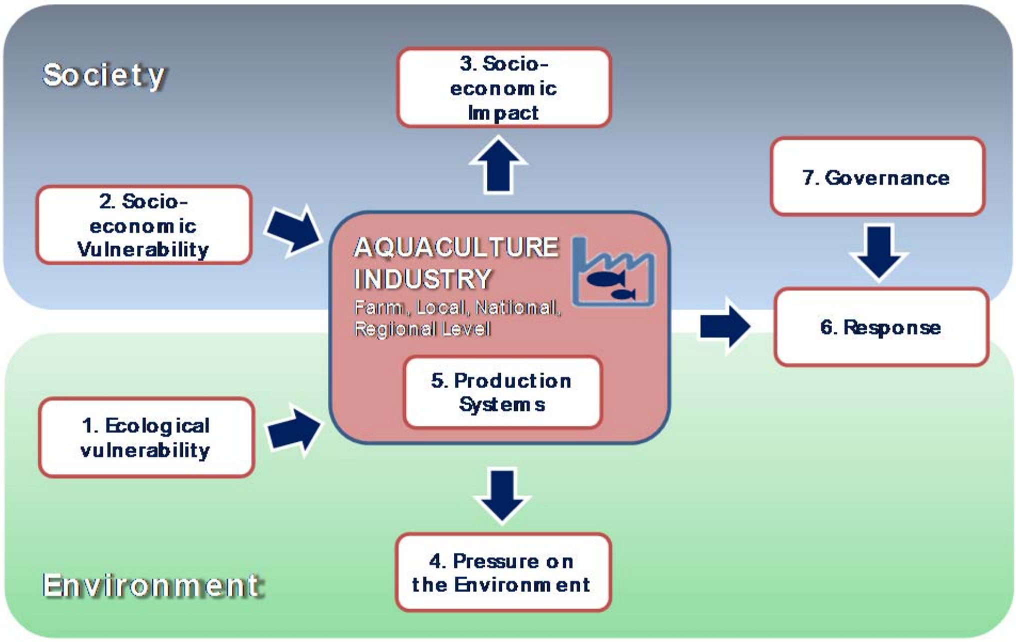


Figure 2. A framework for assessing and monitoring aquaculture development

Box B
Benchmarks considered by InDAM

Atlantic bluefin tuna sold at the fish market in Rome, photo ©FAO Aquaculture photo library/Valerio Crespi.

- Common criteria and related indicators to describe the level of aquaculture sustainability are a necessity in the GFCM area.

- Meeting economic, social and environmental demands with a common reference system is an essential condition for the responsible development of marine aquaculture in the GFCM region.

- A participatory approach is essential in the identification process.

- Indicators should always take into consideration the dimensions of sustainability (economic, social, environmental, and overarching governance).

- The objective for the use of indicators should be considered within the sustainable reference system identified (principles-criteria-indicators) and specified in a multidisciplinary context of aquaculture development.

- The objective for which each indicator is identified should be adapted to Mediterranean peculiarities in terms of aquaculture (species reared, technology applied, local and cultural heritage, etc).

- Standards and reference points should be associated to each indicator.

- Indicators should be considered for communication between farmers and society.

- If indicators are selected within the framework of integrated coastal zone management (ICZM), multi-stakeholder consensus should be reached for their identification at local level.

- The geographical scale (regional, national, local, farm) of indicators should be defined when an indicator is selected.

Based on the above framework and on a comprehensive review of initiatives to develop sustainability indicators for aquaculture (Mathé *et al.*, 2011a), aquaculture indicators can be classified per type and function, as reported in Table II.

Table II: Classification of indicators according to the types and main functions identified

N°	Type	Definition	Function
1	Ecological vulnerability	Characteristics of the elements of the natural environment that constitute a constraint to aquaculture sustainability.	Availability of inputs; water quality.
2	Socio-economic vulnerability	Characteristics of the elements of the socio-economic environment that constitute a constraint to aquaculture sustainability.	Training; interaction with other users; access to information.
3	Socio-economic impact	Indicator to monitor the state and impacts on the socio-economic system.	Economic and social impacts.
4	Pressure on environment	Environmental impact in terms of pressure associated with aquaculture activities.	Pressure on aquatic and terrestrial environments; global pressure and energy consumption.
5	Production method	Indicators referring to the aquaculture production method.	Marketing; animal health and welfare; feed; profitability.
6	Response	Indicator measuring the efforts implemented (schemes or mechanisms) to attenuate pressure.	Control at farm level (individual response); collective management.
7	Governance	Indicators regarding processes of steering and regulation of the industry or the territory.	Openness of the sector; compliance with regulations; institutional maturity.

Source: from Mathé *et al.* (2011a) modified.

Sometimes to measure multidimensional concepts which cannot be captured by a single indicator – e.g. sustainability – a composite indicator[5] could be used. However, composite indicators are subjective and provide a synthetic view of sustainability with consequent loss of information (Mathé *et al*., 2011b).

4.3 Level of applicability of indicators

As it occurs in the capture fisheries sector, answers and information about sustainable aquaculture development require different questions at different levels (FAO, 1999). The construction of a system of indicators for the sustainable development of Mediterranean aquaculture needs to take into account the geographical extension of the area, the variety of the contexts and the diversity of aquaculture farms. Therefore, the Mediterranean and Black Sea require the construction of a common set of indicators, on the one hand, and of country-specific indicators, on the other hand (Mathé and Rey-Valette, 2011).

The Guide considers four geographical levels – or scales – of indicators, namely the regional level, national level, local level and farm level, according to their purposes, practical use and application (GFCM, 2011b).

The level, or scale, of an indicator plays an important role for data collection, monitoring or reporting (displaying). Some indicators can be used for all levels whereas some others are only applicable to one or few levels. For instance, the feed conversion ratio (FCR) is a farm-specific indicator, but it can also be monitored at local, national or regional scale and reported or displayed accordingly. Another example is the indicator on the existence of aquaculture-specific legislation, a country-specific indicator in its scope that could also be used at regional level. The following table illustrates the scale of indicators considered in this Guide and their broad definition.

[5] A composite indicator is formed when individual indicators are compiled into a single index on the basis of an underlying model (OECD, 2008).

Table III: Definition and level of applicability of indicators

Level	Definition of level	Level of applicability	Target users
Regional	Indicators applied to monitor or assess the sustainable development of aquaculture at a determined geographical region.	The indicators identified at regional level should be considered as appropriate for the whole Mediterranean and Black Sea area and for the description of aquaculture sustainability at regional level. The set of indicators should be considered as a tool at the disposal of GFCM countries to plan and monitor the development of sustainable aquaculture and to harmonize strategies.	Regional fishery management organizations (RFMOs) / international organizations
National	Indicators applied to monitor or assess the sustainable development of aquaculture in a specific country.	National indicators encompass an entire country and describe the state and trends of aquaculture sustainability in a given nation giving a holistic picture of the aquaculture sector and its environment.	National governments
Local	Indicators applied to monitor or assess the sustainable development of aquaculture in a specific national area.	Indicators at local level are meant for a homogenous cluster of farms or group of aquaculture operations which, for example, are in close proximity to each other, such as for instance cages in the same bay, municipality, shared resources or infrastructures, county, autonomous region etc. These indicators are more linked to the local communities and could be changed according to the requirements and conditions for the sustainable development of aquaculture in a specific area. This set of indicators could also be considered as a communication tool between farmers and local communities.	National governments/ local authorities / aquaculture farmer's organizations / farmers
Farm	Indicators applied to monitor or assess the sustainable development of a single aquaculture farm.	Indicators at farm level are targeting single aquaculture operations and their close surroundings. Farms can operate in isolation from other farms or be part of a homogenous cluster of farms (i.e. polygon). Some indicators are only applicable at farm level and can provide an operational as well as strictly managerial tool.	National governments / local authorities / aquaculture farmer's organizations / farmers

Source: (GFCM, 2011f).

4.4 Principles–criteria–indicators (PCI) approach

Linking indicators to the principles related to each dimension of sustainable aquaculture could be done by adopting the principles–criteria–indicators (PCI) framework (Rey-Valette *et al*., 2008). The PCI approach establishes a cascading relationship between principles (which express the values and issues of sustainability), criteria (variables that are most appropriate to express these principles), and indicators (variables to be measured).

DIMENSIONS

Dimensions are the key elements of sustainable aquaculture: economic, social, environmental and governance (see par. 3.1).

PRINCIPLES

Principles are associated to the dimensions of sustainable aquaculture. They are the high-level goals to address an issue and determine the criteria and indicators to be selected.

CRITERIA

Criteria break down each principle into specific themes or characteristics and specify the issue to be addressed through the relevant variables to be monitored.

INDICATORS

Indicators allow the criteria to be qualitatively or quantitatively measured, and are essential to monitor or assess the behaviours of the criteria over time.

4.5 Presentation of indicators through methodology sheets

The methodology sheet is a useful framework for the definition of a wide variety of indicators at every level (FAO, 1999). The following glossary provides the definition of the terms used in the indicators methodology sheets. The Guide uses the agreed definition of terms taken from the EVAD project, which were discussed and approved by the WGSA. An example of methodology sheets – one for each dimension – is provided hereafter (Rad *et al*., 2011; Hadj Ali Salem *et al*., 2011).

DEFINITION

This part outlines why the selected indicator has been chosen, the set of underlying reasons for the use of a specific indicator and how that indicator can contribute to the sustainability of aquaculture.

METHODOLOGICAL ASPECTS

The methodological part provides guidance on the particular procedure, or set of procedures, and frequency for the measurement of an indicator.

REFERENCE POINTS & STANDARDS

Reference points indicate the particular state of the element to be monitored. Once an indicator is associated with its standard, it is possible to have a reference point indicating the particular state of the element to be monitored.

DATA SOURCE & AVAILABILITY

This section describes where the required data and information can be sourced. It also indicates the availability of such data and information and highlights potential difficulties in retrieving them.

DIMENSION

Economic

PRINCIPLE

Strengthen risk assessment and crisis management capabilities

CRITERIA

Level of input self-sufficiency

INDICATOR

“Share of imported fry in net national apparent use of fry”
Level of application: regional ____ local_____ national __✓___ farm ____

DEFINITION

Self-sufficiency in terms of inputs used in aquaculture production is a major policy issue for the development of sustainable aquaculture operations. Fry is one of the major inputs used in the production of farmed products. The availability of local hatcheries and fry is therefore of primary importance not only for ensuring sustainable supply of farmed products but also to mitigate the costs and risk associated to imported fries.

METHODOLOGICAL ASPECT

Calculation/formula (at national level):
(Number of imported fry in a specific year ÷ Net apparent use of fry in a specific year) x 100.
Net apparent use of fry in a specific year = Total number of locally produced fry - number of exported fry + number of imported fry.
Segmentation: species-specific (e.g. European seabass, seabream, meagre, etc.)

REFERENCE POINT & STANDARD

Vulnerable ≥30% ≤20%

DATA SOURCE & AVAILABILITY

Data on imported and exported fry can be obtained from the Customs or from affiliated administrations. Data on total domestic production of fry can be collected from local hatcheries.

Source: InDAM pilot study in Turkey (Rad *et al.*, 2011).

DIMENSION

Environmental

PRINCIPLE

Minimize the global impact of aquaculture

CRITERIA

Needs of the natural resource (pelagic fish and plants)

INDICATOR

“Feed conversion ratio (FCR)”
Level of application: regional ____ local_____ national __✓___ farm ____

DEFINITION

The feed conversion ratio (FCR) is the ratio between the dry weight of feed fed and the weight of yield gain (FA0, 2008). FCR is an appropriate threshold minimizing the global and local impacts of aquaculture. This is because it is an indication that minimal waste food is entering the environment.

METHODOLOGICAL ASPECT

Calculation/formula:
FCR = kg of feed that are used to produce one kg of whole fish.
It is a measure of the efficiency of the conversion of feed into fish (e.g. FCR = 1.8 means that 1.8 kg of feed is needed to produce 1 kg of fish, live weight).

REFERENCE POINT & STANDARD

Reference values/baseline/standard: species-specific
Implementation frequency: annually or every 3-5 years

DATA SOURCE & AVAILABILITY

Literature, expert consultations and data from the field.

Source: InDAM pilot study in Turkey (Rad *et al.*, 2011).

DIMENSION

Social

PRINCIPLE

Contribute to food security and healthy nutritional needs

CRITERIA

Accessibility of products to local consumers

INDICATOR

"Share of aquaculture in the apparent consumption"

Level of application: regional ____ local_____ national __✓___ farm ____

DEFINITION

This indicator measures the contribution of aquaculture to the national population's satisfy food needs in marine animals. The degree of aquaculture development and sustainability can be deduced from the evolution of this indicator over the medium and long term.

METHODOLOGICAL ASPECT

Calculation/formula:
Share of aquaculture in apparent consumption = AQP/ (CFP + AQP + IMP-EXP).
AQP: aquaculture production; CFP: capture fisheries production; IMP: imports by weight for human consumption; EXP: exports by weight).

REFERENCE POINT & STANDARD

≥10% ≤25%

Reference values/baseline/standard: This indicator could be compared to the worldwide share of aquaculture in the total production of the sector (fisheries and aquaculture) which is, without China, about 25%. The minimum limit for this indicator could be the projected percentage for aquaculture (10%) in the latest Tunisian development plan

DATA SOURCE & AVAILABILITY

The data needed for the construction of this indicator are very well known and available at the General Direction of Agricultural Production (DGPA Tunisia

Source: InDAM pilot study in Tunisia (Hadj Ali Salem *et al.*, 2011).

DIMENSION	***Governance***
PRINCIPLE	Strengthening risk assessment and crisis management capabilities
CRITERIA	Level of property rights over production sites
INDICATOR	**“Existence of national legislation on AZA: % of allocated zones for aquaculture”** Level of application: regional ____ local_____ national ✓ farm ____
DEFINITION	To ensure a place for aquaculture in the management plans for integrated coastal zone management (ICZM), there is an exclusive occupancy plan for aquaculture projects. The definition of an allocation plan for aquaculture zones aims at protecting aquaculture projects and ensuring their sustainability
METHODOLOGICAL ASPECT	Calculation/formula (at national level): Yes/No - if Yes: % of allocated zones to aquaculture = (aquaculture reserved area/total coastal marine area)*100.
REFERENCE POINT & STANDARD	Reference values/baseline/standard: No reference point is available at the moment; because all Tunisian farms are not certified (Statistical analysis of a time series of data is required for the traffic-light approach).
DATA SOURCE & AVAILABILITY	Information available at the competent supervisory services (DGPA Tunisia).

Source: InDAM pilot study in Tunisia (Hadj Ali Salem *et al.*, 2011)

5. SELECTION AND USE OF SUSTAINABLE AQUACULTURE INDICATORS

Floating cages aquaculture, Turkey, photo ©FAO Aquaculture photo library/Raymon van Anrooy.

5.1 General considerations on the process of selection of indicators

The procedures for the selection or identification and use of indicators for sustainable aquaculture follow the most generalized approach used in building indicators for sustainable development (Mathé *et al.*, 2011a), as it is summarized in Fig. 3. The steps presented are also based on the experience and lessons learnt from several initiatives including pilot studies implemented within the InDAM project. The whole process suggested here should be intended as a dynamic undertaking which might vary in its implementation in order to adapt to the spatial and temporal scale considered. Therefore, the following steps only should be considered as a broad roadmap, while the final methodology to be used in the whole selection process of indicators totally rests with each country.

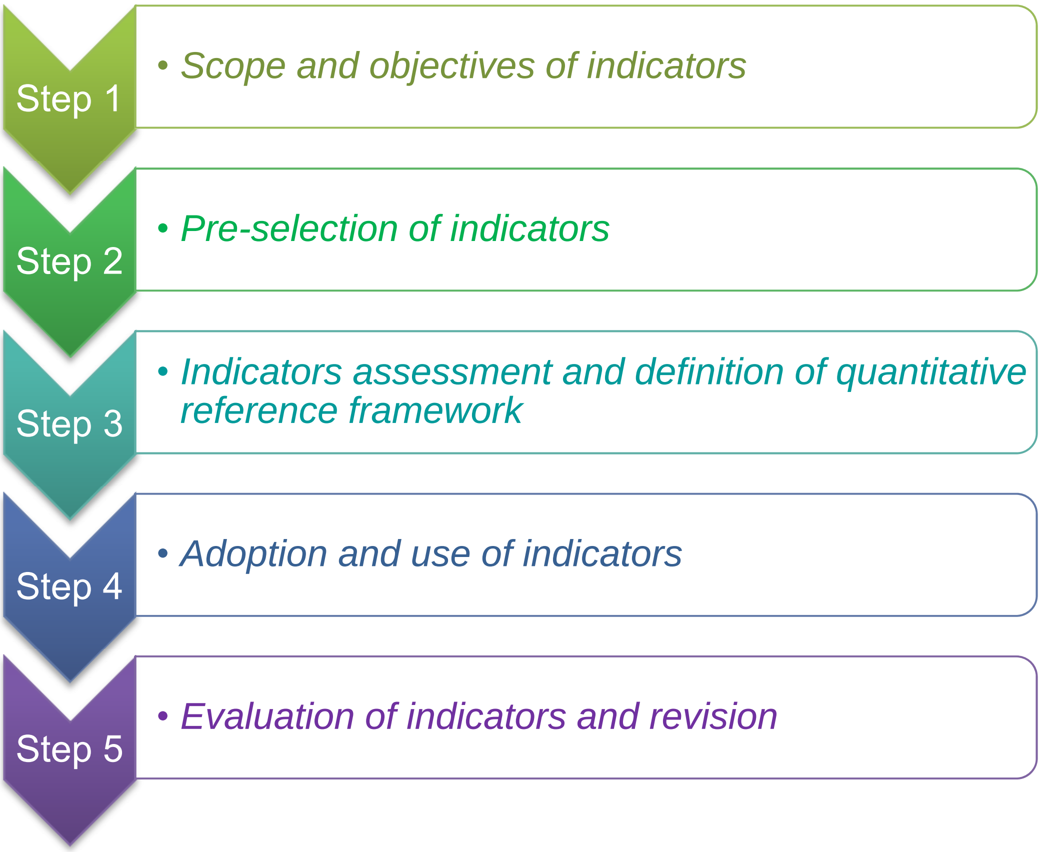


Figure 3. The general process of selection and use of indicators

5.2 Step 1: Scope and objectives of indicators

At the beginning of the process, the objective – or range of objectives – indicators are trying to achieve need to be identified. The first step towards the selection and use of indicators of sustainability should be initiated by the final users of such indicators, being them the authorities with competence in aquaculture either at regional or national level, local administrations, and policy makers. Although these initiators are crucial, the different steps in the entire process should be followed and driven by a "focus group discussion" (Rad *et al.*, 2011; Hadj Ali Salem *et al.*, 2011) normally involving experts with different backgrounds (e.g. economic, environmental or social sciences) with whom the initiators will work together to clearly define the scope, objectives and scale of the indicators. They will also agree upon the general conceptual framework for assessing and monitoring the development of sustainable aquaculture.

In general, the whole process could follow the "co-construction approach", that is be highly participatory by involving key stakeholders in the aquaculture sector, e.g. farmers, fishermen, aquaculture farmers' organizations, ministries and government institutions, research bodies, NGOs, local communities and civil society. The multi-stakeholder consensus-based process is important as a means and as an end. As a means, it is useful for tweaking the selection of indicators (e.g. reducing, merging and renaming indicators, proposing new ones and moving indicators to other dimensions, testing their practical applicability in the field and identifying reference points and standards). As an end, it is instrumental in bringing together and building a channel of communication and lasting dialogue among stakeholders. This would result in social capital such as ownership, stewardship and commitment and would arguably allow for an improved compliance to rules and regulations.

Box C
The EVAD project and the co-construction approach

Traditional eel capture, Veta la Palma fish farm, Spain, photo ©Herminio Muñiz

The co-construction methodology is a joint approach to building indicators, which is procedural, adaptive and participatory and aims at promoting collective learning in order to implement a sustainable aquaculture. It builds on the achievements of the EVAD research project. The main advantages of implementing a co-construction approach have been recognized as follows:

- It offers the opportunity to define the challenges of sustainable aquaculture development collectively and at various scales;
- It is a joint approach to building indicators which is procedural, adaptive and participatory;
- Stakeholders involvement along the consultative process results in increased awareness of the objectives guiding the implementation of sustainable development, ownership of the system of indicators and actual use of them;
- It provides a roadmap within a flexible reference framework where the most relevant principles, criteria and indicators can be selected from a wide pool of choices and according to the challenges, areas and types of aquaculture concerned; and
- The process can lead to a formalization and institutionalization of the indicators.

Source: Rey-Valette *et al.*, 2008

5.3 Step 2: Pre-selection of indicators

The second step aims at performing a pre-selection of indicators to be used at farm, local and national level. A source of available indicators can be useful to start the pre-selection of indicators. For instance, a set of 14 principles, 67 criteria and 156 indicators has been identified within the framework of the InDAM project, during its first phase (GFCM, 2011c). This basket of indicators could represent a starting point for further selection processes. Additional indicators could also be added as appropriate and according to exchanges between the focus groups and key stakeholders. It is advisable to use quantitative tools to perform the first selection. The methodology for the pre-selection of indicators could foresee the following activities:

- Organization of a technical meeting with a discussion group including a wide representation of key stakeholders (farmers, fishermen, aquaculture farmers' organizations, ministries and government institutions, scientists, NGOs, local communities and civil society);
- Discussion on an initial set of preselected indicators identified, possibly starting from an available set of indicators already identified in order to facilitate the selection process and stimulate discussion (GFCM, 2011c);
- Prioritization of attributes of indicators;
- Selection process based on the priorities identified by stakeholders; and
- Validation of the final set of indicators.

Aquaculture farmers at Laguna del Fusaro, Naples, Italy, photo ©Fabio Massa

Box D
Using attributes to pre-select indicators: case studies in Turkey and Tunisia

Fyke nets (*martavelli*), photo ©FAO/Fabio Massa

In 2009, two pilot studies were carried out in Turkey and in Tunisia to initiate a quantitative indicator selection process based on the identification and prioritization of attributes, or qualities, for the selection of indicators by key stakeholders. The initial set was composed of 156 indicators pertaining to the environmental, economic, social and governance dimensions identified by the InDAM project. The exercise started from the following pre-selected pool of 10 commonly used attributes of a good indicator and their definition based on relevant scientific literature:

1. **Relevance** to criteria and principles (it is relevant to the goals of endorsed criteria and principles)
2. **Understandability** (it is clear and perceived by all stakeholders in the same manner and it is easy to communicate)
3. **Reliability** (it has a sound scientific base and methodology with successful previous use)
4. Reproducibility/verifiably (it is reproducible at different times and places and with verifiable results)
5. **Data availability** (it is estimated/produced using available information/data or can be estimated/produced at reasonable costs/efforts)
6. **International compatibility** (it is compatible with other indicators developed by other countries, regions or bodies)
7. **Trasparency** (it is accessible by all stakeholders)
8. **Availability of reference values** (it can be compared/monitored with some readily available reference points)
9. **Acceptability** (it is endorsed by different stakeholders)
10. **Robustness** (it is difficult to manipulate)

Through a process of scoring and ranking of attributes for the selection of indicators which involved the use of structured questionnaires and statistical analysis (Delphi approach), participants in both pilot studies have selected the following four attributes:

1. **Relevance to criteria and principles**
2. **Understandability**
3. **Reliability**
5. **Data availability**

Scores allocated to different attributes reveal that stakeholders with different backgrounds and expertise have different priorities and preferences with regard to attributes and to their use in the selection of indicators. In both countries, the indicators were ranked according to a weighted mean score (WMS) of their four attributes. In Turkey, indicators were divided into two groups whereby "acceptable indicators" had a WMS equal or above 5. Consequently, the initial set of 156 indicators was reduced to 116: 41 environmental, 31 economic, 12 social and 32 indicators belonging to governance dimensions were pre-selected for implementation at sectoral level. In Tunisia, the indicators were ranked in three groups as follows: "highly acceptable indicators" (WMS > 66th percentile); "acceptable indicators" (33rd percentile ≤ WMS ≤ 66th percentile); and '"weakly acceptable indicators" (WMS < 33rd percentile). The exercise resulted in a total of 52 pre-selected indicators: 18 environmental, 17 economic, 6 social and 11 governance dimensions.

Source: GFCM, 2011c.

Box E
Selection of indicators using the Delphi method: the Spanish pilot study

European eel nursery in a closed recirculating system, Tunisia, photo ©FAO Aquaculture photo library/Valerio Crespi.

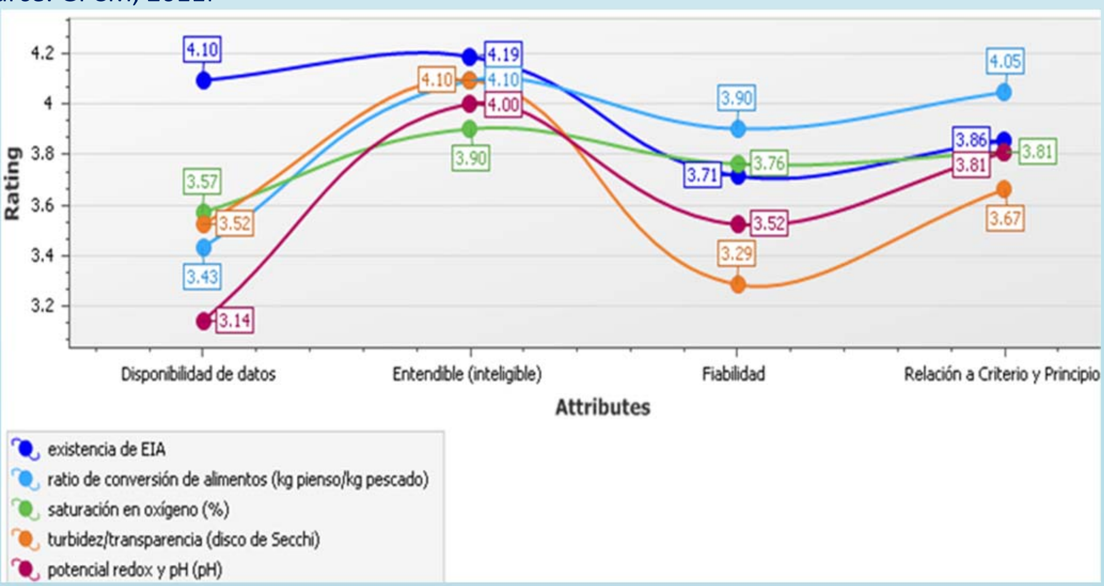
The Delphi method is an expert-driven process which aims to generate consensus on specific matters. It implies the preparation of a questionnaire designed to transpose qualitative parameters (in this case, the rating of each indicator/variable against a given set of attributes) into discrete values.

Following a first questionnaire round, a preliminary analysis is run to process the collected opinions and provide the participants with a statistical feedback. Additional phases are usually foreseen in order to operate optimizations on the original questionnaires on the basis of the outcomes already collected (e.g. redeployment of specific parameters into other dimensions) and to perform further questionnaire rounds to achieve pre-determined consensus levels (70 percent is often being considered as a reasonable threshold).

The preselecting and selecting process of indicators can be facilitated through the application and use of a Delphi method. During the InDAM pilot study in Spain, the Delphi method was applied by the GFCM Secretariat and used to evaluate and rank a list of 170 indicators (additional indicators suggested by the Mediterrane-On project were added to the 156 InDAM indicators), based on the same four prioritized attributes as applied in the pilot study in Turkey and Tunisia.

The Delphi method has proven to be a flexible, cost-effective and efficient tool to achieve a strong consensus among experts.

Source: GFCM, 2011f



5.4 Step 3: Indicators assessment and definition of quantitative reference framework

The third step aims at assessing the applicability of pre-selected indicators identified during step 2. The major outputs of step 3 will be a set of indicators including methodological sheets outlining the level of applicability (farm, local and national level), definitions, the methodology to measure the indicator (formula and calculation), the reference values/baselines/standards, and the sources of data and information. A qualitative approach to go into a deeper analysis through focus group consultations supported by indicator methodology sheets is also suggested. Testing and feedbacks from experts and stakeholders can complete the process and include a general discussion and agreement on reference points and values.

The proposed methodological framework for the implementation of a system of indicators at local level could be summarized as follows:

Preparatory stage and pre-identification of indicators

- Consider indicator methodology sheets for discussing and assessing the applicability of the pre-selected indicators;
- Organize a technical meeting with key stakeholders for focus-group discussions.

Technical meeting

- Review and assess indicators based on agreed methodology sheets for the pre-selected indicators (e.g. based on the selection of indicators attributes);
- Merge and rename pre-selected indicators if necessary;
- Propose additional indicators, if any, including methodological aspects;
- Develop reference values/baselines/standards for monitoring indicators.

Validation of selected indicators

- Discuss with key stakeholders, i.e. aquaculture farms, feed manufacturers, packaging/processing plants to further test and validate the applicability of pre-selected indicators.

Finalization of selected indicators

- Reassess and fine-tune indicators, including methodological aspects and reference values/baselines/standards.

Harvesting operation in marine cage farm in Bodrum, Mugla, Turkey, @FAO Aquaculture photo library/FAO SEC

Box F
Assessment and final selection of indicators at local level: the InDAM pilot studies in Turkey and Tunisia

Fish market, photo ©FAO/Fabio Massa.

Turkey: in September 2011, a technical meeting was organized to assess the 116 pre-selected indicators during step 2 in 2009. The meeting was attended by 33 participants including fish farmers, farm managers, food safety managers, aquaculture farmers' organization representatives, administrators/technocrats and researchers in different disciplines (e.g. aquaculture, veterinary sciences, social and administrative sciences, agricultural economics, environmental sciences, fish nutrition and feeding and fish processing technology). The methodology was based on focus-group discussions and testing of indicators through field visits. Indicators methodology sheets were prepared for the pre-selected indicators to be used during the focus-group discussions. The initial set of pre-selected 116 indicators related to the economic, environmental, social and governance dimensions were discussed and assessed during focus-group meetings, using context and data-specific quality attributes. The applicability of indicators was further verified through field visits. As an output of the step 3 exercise, a total of 33 indicators (7 economic, 8 environmental, 10 governance and 8 social) were identified as applicable either at farm, local or national level. Finally, for the economic dimension, 3 indicators were considered as potentially applicable due to difficulties in accessing enterprise's financial data, and 3 new indicators were proposed and developed during focus-group consultations. For the environmental dimension, 4 indicators were spotted as potentially applicable and 2 new indicators were identified (Rad *et al.*, 2011).

Tunisia: in June 2011, a technical consultation meeting was organized to assess the pre-selected indicators which were identified in 2009 during step 2. Prior to the meeting, the Working Group had further narrowed down the pre-selected indicators from 52 to 40 indicators (19 economic, 17 environmental, 2 governance and 2 social) and prepared the methodology sheets for those indicators. The meeting was attended by 50 participants including farmers, feed manufacturers, drugs and fingerling suppliers, banks, researchers, university and administration representatives. Similarly to the Turkey meeting, the methodology was based on focus-group discussions. The exercise resulted in 24 indicators (14 economic, 7 environmental, 2 governance and 1 social). Subsequently, in September 2011, a second technical meeting was organized to further test and assess the applicability of indicators. This meeting was hosted by the General Directorate of Fisheries and Aquaculture and was attended by 20 participants, many of which were farmers. At the end of this process, 13 key indicators were chosen (4 economic, 6 environmental, 1 governance and 2 social). Finally, field visits to marine farms were organized to validate the selected indicators and to agree on reference points when available (Hadj Ali Salem *et al.*, 2011).

Key points

- The number of indicators in the final set should be kept to a minimum to avoid cluttering up the overview of the complex system it is meant to provide.
- It is important to strike a balance between all dimensions of sustainable development.
- The participative process builds a communication channel and dialogue among the aquaculture stakeholders.
- The involvement of policy-makers and aquaculture competent authorities in the process has created ownership and made the acknowledgment and adoption of selected indicators easier.

5.5 Step 4: Adoption and use of indicators

Once the indicators have been assessed and finalized, the following step should focus on the adoption and use of indicators at the appropriate level and according to target users. To this end, the fourth step is meant to achieve deeper involvement of administrations and other key stakeholders towards a direct application of the selected indicators. A good indicator is an indicator that is used (Rey-Valette *et al*., 2008) and, therefore, this step is fundamental to achieve ownership and adoption of the indicators by the end-users, be them aquaculture competent agencies, authorities at local, national and regional level, NGOs, aquaculture farmers' organizations or farmers. Organizing workshops with the main stakeholders, focusing on raising awareness and obtaining broader consensus on the concept of sustainability should be a core element to promote the development of sustainable aquaculture and the implementation of any monitoring scheme using sustainability indicators. Thus, involving from the beginning of the process a wide range of stakeholders, including policy-makers and aquaculture competent authorities, is crucial for the adoption and future use of indicators (Table IV).

Table IV: Indicators at different scales should be used by different bodies

Level	Target users
Regional indicators	Regional fishery management organizations (RFMOs) / International organizations
National indicators	National governments
Local indicators	National governments / Local authorities / Aquaculture farmers' organizations / Farmers
Farm indicators	National governments / Local authorities / Aquaculture farmers' organizations / Farmers

The Guide suggests a minimum set of regional indicators, defined as a minimum common number of indicators that could be applicable in each country within the GFCM region (Appendix 2). It includes a total of 21 indicators distributed as follows: economic dimension (5), environmental dimension (5), social dimension (5) and overarching governance (6).

The following stages summarize the main activities for the use of selected indicators which could be valid for any type of end-user:

- RFMO, international organizations, national governments, local authorities, aquaculture farmers' organizations and farmers acknowledge and adopt a list of selected indicators;
- A protocol for the use of indicators including baseline and routine monitoring is developed and an agency is appointed to perform the assessment and monitoring;
- The methodology for indicators assessment and data visualization is identified;
- Indicators are assessed and monitored regularly.

To facilitate their use within a broader management system and their accessibility to a wider audience, indicators and their interpretation need to be assessed and presented so that they can be easily understood by users. The following paragraphs suggest how to use the traffic-light approach and the radar charts.

5.5.1 Indicators and traffic-light approach to display monitoring and assessment of aquaculture

The traffic-light approach (TLA) is a way to display the values of indicators which makes information readily available and easy to understand; the TLA can also be effectively used to assess the variation of a series of indicators over time (Ceriola *et al.*, 2008).

Traditionally, the TLA has been applied to capture fisheries only (Caddy, 2006; Ceriola *et al.*, 2008) although it has also been used later in aquaculture as well as in the seafood sector to categorize commodities based on their sustainability status. This approach to indicator use offers considerable advantages, especially in terms of simplicity of communication and cost-effectiveness. Using the TLA approach, a judgment codified by a specific colour can be assigned to every range of values or status for a given indicator or group/cluster of indicators (negative = red, intermediate/neutral = yellow, positive = green) based on reference points and standards. Relying on the colour code, the variations of each indicator or group/cluster of indicators can be highlighted and the associated information (e.g. good, intermediate or warning state) made available for assessment and/or analysis.

The three examples below show the use of the TLA to display the reference values of indicators. They are provided both for displaying a given indicator and for assessing a farm through the TLA approach. Further considerations should also be made on the weight of compliance for each dimension of sustainability.

Example 1. Display the value of indicators according to an identified indicator. In this case, the value is determined for the economic and environmental indicators and the thresholds have been discussed and defined by the farmers and other stakeholders during the InDAM pilot study in Turkey (Rad *et al.*, 2011).

Example 1: Display single indicators

- ✓ **Economic indicator 1**

  Existence of quality certification schemes by independent bodies for target market(s)

  Vulnerable — Strong

No quality certification	Planning of quality certification	Quality certification exists
(red)	(yellow)	(green)

- ✓ **Economic indicator 2**

  Unit production cost (€/kg, ex-farm)

  Vulnerable — Strong

>4 €	3-4 €	< 3 €
(red)	(yellow)	(green)

- ✓ **Environmental indicator 1**

  Feed conversion ratio (FCR) - Seabass: 350-400 gr

  Bad — *2.2* — *1.8* — Good

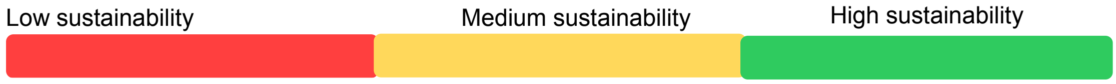
(red)	(yellow)	(green)

Example 2. The TLA can also be applied to assess an aquaculture farm. The degree of sustainability at farm level can be divided into the following three major groups: low sustainability (red), medium sustainability (yellow), and high sustainability (green), and displayed using a TLA system. Disclaimer: the reference values shown in the box below were arbitrarily chosen used just as an example. The choice of reference values for assessing the sustainability of a farm rests totally with each country.

Example 2: Assessing a farm

✓ **Scoring 1**

Use of reference points and TLA assessment for each indicator



Farm is red if:	Farm is yellow if:	Farm is green if:
25% ≤ green indicators <50%	50% ≤ green indicators <75%	75% ≤ green indicators ≤100%
0% ≤ yellow indicators <25%	25% ≤ yellow indicators <50%	0% ≤ yellow indicators <25%
25% ≤ red indicators <50%	0% ≤ red indicators <25%	0% red indicators

Example 3. The TLA can be used when indicators are assessed over a given period of time thus monitoring progress towards sustainable development. This approach can be used at any scale or level, i.e. farm, local, national and regional.

Example 3: Assessing a farm over time

The TLA can be used to monitor a farm over time, i.e. once a year, for a specific set of eight indicators, as illustrated by the following table:

The above table in the example 3 provides a clear visual trend of an aquaculture farm: economic 2, environmental 2 and governance 1 indicators have always shown "a good state" i.e. values within the reference points. On the other hand, economic 1, environmental 1 and social 2 indicators had to be properly addressed before reaching a good state after five years. Finally, both environmental 3 and social 1 indicators show that something happened in the farm over the last 2-3 years causing the indicators to fall in the intermediate and warning state respectively. This is the signal that the management of the farm must identify and address the issues as soon as possible to maintain the entire operation in a good state.

5.5.2 The use of radar charts

A radar chart (also known as web, spider and star chart), is a graphical method of displaying multivariate data, in the form of a two-dimensional diagram, for three or more quantitative variables represented on equi-angular axes starting from the same point. Radar charts can be employed to simply describe the value of a set of indicators or to graphically show the size of the gaps between the value of a set of indicators against benchmark values for those indicators, for example an average value at national level. The data length of an axis is proportional to the value of the indicator for the data point relating to the maximum value of the indicator across all data points. A line is drawn connecting the data values for each axis. The major advantages of using a radar chart consist in the capacity to graphically show areas of strength and weakness, as well as depicting the general overall performance (Fig. 4).

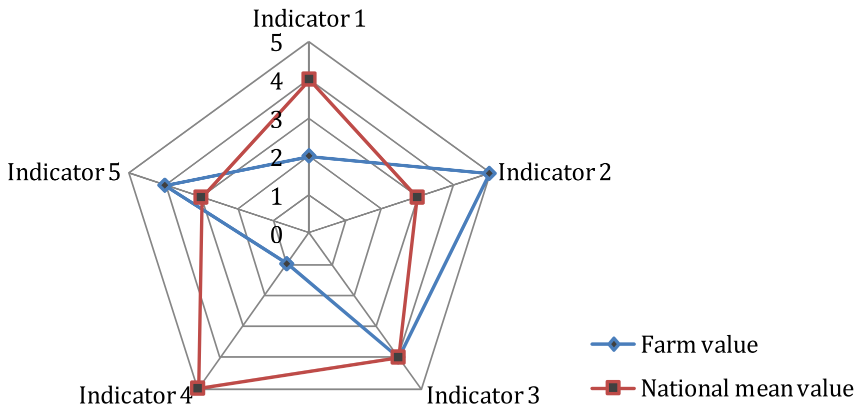


Figure 4. Example of radar chart

Radar charts can be easily generated using Microsoft Excel®, which enables to report the value of each indicator. The chart in Fig. 4 shows the overall performance of a set of five indicators at farm level compared to the average national value of the same indicators. The chart clearly shows that the farm is below the national average for indicators 1 and 4; it is comparable for indicator 3; and it is outperforming for indicators 2 and 5. Radar charts can be used for indicators within the same sustainability dimension or among several dimensions.

5.6 Step 5: Evaluation of indicators and revision

The use of indicators for sustainable aquaculture should be seen as a dynamic process in which the target users play a fundamental role not only in the use of indicators but also in performing regular evaluations and revisions of the indicators and associated standards, reference points as well as methodology sheets. This step should take into consideration developments and updates, changes in reference points and standards, introduction of new species and farming systems, etc. These factors will provide key elements to adapt the overall approach, the conceptual framework, the objectives and the set of chosen indicators.

Effective communication strategy and awareness campaigns on aquaculture sustainability and on the use of indicators should be developed to facilitate the dissemination of best practices and sharing of experiences.

Finally, capacity-building measures on the use of indicators for sustainable aquaculture targeting the main end-users would need to be organized and delivered.

6. OTHER USES OF INDICATORS

Floating cages in the Gaeta Gulf (Italy), photo ©FAO Aquaculture photo library/Valerio Crespi.

The previous chapter of the Guide addressed the assessment and monitoring functions of indicators, which can be employed to assess the sustainability of aquaculture and to monitor trends over time.

Indicators are also being used for other purposes within the aquaculture sector. More specifically, indicators (and, in general, criteria and principles which underpin them) can also be used in codes of conduct and best practices, as well as in the definition of standards for regulatory frameworks, certification and labelling.

Table V: Summary of examples of other uses of indicators in aquaculture

Function	Definition
Code of conduct	Indicators for sustainable aquaculture can form the basis of a new code of conduct. For example, the Federation of European Aquaculture Producers (FEAP) has used the indicators developed by the CONSENSUS project as an integral part of a major revision of its 2000 Code of conduct for European finfish aquaculture.
Code of practice and better management practices	Principles, criteria and indicators can be used as a basis to develop locally specific codes of practice (CoP) and better management practices (BMPs), which could be considered as the most technically practical and economically feasible methods currently available to reduce the adverse environmental impacts of aquaculture at farm level and also at a larger scale.
Aquaculture legislation	Indicators and their standards/reference points can be part of country legislation. Financial or other kind of benefits could be granted to those farmers who comply with these standards/reference points.
Aquaculture certification	Principle, criteria and indicators are also the starting point for the development of standards and certification and labeling programmes for responsibly farmed seafood.

Each of the above uses will be briefly addressed in the next paragraphs.

6.1 Codes of conduct, codes of practice and better management practices

In the field of aquaculture, codes of conduct (CoC), codes of practice (CoP) and better management practices (BMP) are non-mandatory documents which target sustainable aquaculture production. In 2000, the Federation of European Aquaculture Producers (FEAP) has developed a code of conduct where the indicators developed through the CONSENSUS project[6] have been incorporated. CoP for the production of a wide range of aquaculture species have been developed in several aquaculture producing regions, primarily in the Asia-Pacific region (Corsin *et al.*, 2008). These documents are most often produced by industry organizations and are aimed at describing the practices to be adopted to achieve sustainable production. Similarly to CoP, BMP also describe practices for sustainability. An approach which was also initiated in the Asia-Pacific region, BMP are generally practices focused on small-scale forms of production and have received considerable support from FAO.

[6] CONSENSUS is a European Commission (EC) funded initiative towards sustainable European aquaculture, aiming at building sustainable aquaculture protocols based on low environmental impact, high competitiveness and ethical responsibility with regard to biodiversity and animal welfare (http://www.euraquaculture.info).

The Network of Aquaculture Centres in Asia-Pacific (NACA, 2001-2012) defines CoC, CoP and BMP as follows:

- **Code of conduct (CoC)** is usually an “overarching document” comprising a set of principles and criteria that may be used as the basis for certification.
- **Code of practice (CoP)** is usually a “lower level” document that provides guidance on management or other practices to be adopted in implementing the principles of the codes of conduct.
- **Better management practices** (BMP) are “management practices” aimed at increasing both the quantity and quality of products taking into consideration food safety, animal health, environmental and socio-economical sustainability.

Following the above definitions, it would therefore seem possible to use indicators to develop CoP or BMP for Mediterranean and Black Sea aquaculture. CoP/BMP would then be considered as the most technically practical and economically feasible methods currently available to reduce adverse environmental and social impacts of aquaculture at the farm level. The inclusion of the indicators in CoP or BMP may also bring better access to markets. In addition, developing CoP/BMP would contribute to communicating positive messages about the industry, hence improving its image with society and consumers. The development of CoP/BMP should ideally be conducted through multi-stakeholder consensus-based processes, although most often these are more limited than the processes adopted in aquaculture certification. This may best be channelled through an existing farmers’ organization to increase synergy and avoid overlapping and confusing messages to consumers. However, if the objective of this adoption of the indicators is just to improve production, and not to communicate about it, then a new effort would be possible.

6.2 Aquaculture legislation

Sustainability within a country is generally the responsibility of a government. In fact, governments are responsible for developing legislation to address food safety, environmental and social issues. Governments also set up strategies that affect governance within the sector and are concerned with the economic viability of businesses. For this reason, indicators and their standards/reference points could also be included into the legislation. This would be beneficial to governments as they would show openness through multi-stakeholder consensus-based processes. It would also be profitable to producers as there would be an alignment with other uses of the indicators.

Although indicators can be readily used to develop legislation, it is important to pay attention to the levels used to set standards/reference points. In fact, if indicators are to be used as part of a voluntary programme (e.g. to develop CoP) stricter standards can be set. On the contrary, because of the mandatory nature of legislation, setting strict standards as part of legislation would make non-compliant farms illegal.

6.3 Aquaculture certification

Certification is the process through which an independent organization assures that a product or process is in compliance with a given set of standards. Over the past decade, aquaculture certification has been growing at an outstanding speed. There are now about 30 aquaculture certification schemes/initiatives. Of these, several are niche schemes such as organic or animal welfare programmes.

The following are three examples of aquaculture certification schemes:

- **Aquaculture Stewardship Council (ASC).** Funded by the WWF and the Sustainable Trade Initiative (IDH) in 2009, it has already obtained the support of retailers and buyers in Europe and North America. ASC is an eco-label that builds on experiences from the Marine Stewardship Council (MSC) and Forest Stewardship Council (FSC). At present, there are standards (either finalized or under development) for tilapia, pangasius, trout, salmon, cobia, amberjack, shrimp, bivalves and abalone.

- **GlobalGAP.** It is a retailer-led scheme which was initially focused on agriculture/livestock products and was created to harmonize retailers' requirements. Over the past five years, GlobalGAP has also expanded its scope to aquaculture. Initially set with species-specific standards, GlobalGAP now features a single set of standards applicable to all forms of aquaculture, provided they are produced in hatcheries. GlobalGAP benefits from a strong recognition by European retailers. GlobalGAP is a business-to-business (B2B) scheme; hence it does not lead to a label on the product.

- **Global Aquaculture Alliance (GAA).** It is an aquaculture industry organization established in 1997. In the early 2000s, GAA started developing the Best aquaculture practice (BAP) standards for shrimp aquaculture. This effort gradually expanded to include other species groups such as tilapia, pangasius, catfish and salmon. BAP standards are primarily recognized in the United States and in the United Kingdom. Compliance with BAP standards is indicated thanks to a label on the package.

It may be possible to use indicators within a context of certification by proposing a certification scheme to host the indicators/standards (perhaps with some modifications). This would imply the need to follow the newly approved FAO Technical Guidelines on Aquaculture Certification (FAO, 2011) and to establish a sound multi-stakeholder mechanism to identify the standards/reference points, accredit assessors/auditors, and assess farms.

7. BIBLIOGRAPHIC REFERENCES

Alcamo, J., Ash, N.J., Butler, C.D. *et al.* 2003. *Ecosystem and human well-being. A framework for assessment/Millennium Ecosystem Assessment.* Washington, DC, Island Press. 245 pp.

American Public Health Association (APHA). 1992. *Standard Methods for the Examination of Water and Wastewater*, 18th Edition. Washington, DC, American Public Health Association.

Asian Development Bank. 2000. *Handbook for the Economic Analysis of Health Sector Projects*. Manila, Philippines, ADB. 156 pp.

Àvila Zaragoza, P. 2011. *Indicators for the sustainable management of coastal lagoons areas*. Presentation for the GFCM Workshop on Mediterranean coastal lagoons management: interaction between aquaculture and capture fisheries, Cagliari, Italy, 28–30 June 2011.

Barazi-Yeroulanos, L. 2010. *Synthesis of Mediterranean marine finfish aquaculture – a marketing and promotion strategy*. Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 88. Rome, FAO. 198 pp.

Blackhart, K., Stanton, D.G. & Shimada, A.M. 2006. *NOAA Fisheries Glossary.* NOAA Technical Memorandum NMFS-F/SPO-69, 71 pp.

Bondad-Reantaso, M.G.& Prein M., eds. 2009. *Measuring the contribution of small-scale aquaculture: an assessment*. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180 pp.

Bondad-Reantaso, M.G., Bueno, P., Demaine, H. & Pongthanapanich, T. 2009. Development of an indicator system for measuring the contribution of small-scale aquaculture to sustainable rural development. *In* M.G. Bondad-Reantaso and M. Prein, eds. *Measuring the contribution of small-scale aquaculture: an assessment,* pp. 161–179. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180 pp.

Boyd, C.E. 2000. *Water Quality. An Introduction*. Boston, Dordrecht, London, Kluwer Academic Publishers. 325 pp.

Boyd, H. & Charles, A. 2006. *Creating community-based indicators to monitor sustainability of local fisheries.* Ocean & Coastal Management 49, 237–258.

Byron, C.J. & Costa-Pierce, B.A. 2010. *Carrying Capacity Tools for Use in the Implementation of an Ecosystems Approach to Aquaculture.* Presented at the FAO Expert Workshop on Aquaculture Site Selection and Carrying Capacity Estimates for Inland and Coastal Waterbodies. Institute of Aquaculture, University of Stirling, Stirling, UK, 6–8 December 2010.

Boulanger, P.M. 2004. *Les indicateurs de développement durable: un défi scientifique, un enjeu démocratique.* Working papers No 21/2004. IDDRI 24 pp.

Caddy, J.F. 2006. The potential use of indicators, reference points and the traffic light convention for managing Black Sea fisheries. *In* G. Lembo, ed., S*elected Papers Presented at the Workshop on Biological Reference Points*, Rome, 20–21 April, 2004. Studies and Reviews. General Fisheries for the Mediterranean. No. 83. Rome, FAO. 1–24.

Cataudella, S., Massa, F. & Crosetti, D., eds. 2005. *Interactions between aquaculture and capture fisheries: a methodological perspective.* Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 78. Rome, FAO. 229 pp.

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.

Gueneuc, T. Tocqueville, A. Aubin, J. Timsit M. & Michel, G. 2010**.** *Guide méthodologique: les indicateurs de durabilité pour l'aquaculture*. CIPA – ITAVI. 97 pp.

Corsin, F., Mohan, C.V., Padiyar, A., Yamamoto, K., Chanratchakool, P. & Phillips, M.J. 2008. Codes of practice and better management: a solution for shrimp health management? *In* M.G. Bondad-Reantaso, C.V. Mohan, M. Crumlish & R.P. Subasinghe, eds. *Diseases in Asian Aquaculture.* VI. Fish Health Section, pp. 419–432. Manila, Philippines, Asian Fisheries Society. 505 pp.

Corsin, F. 2009. Indicators and standards for responsible aquaculture production. *In* M.G. Bondad-Reantaso & M. Prein, eds. *Measuring the contribution of small-scale aquaculture: an assessment.* pp.125-134. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180 pp.

Crespi, V. & Coche, A. (comps). 2008. *Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura.* Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese)

Deniz, H. 2012. *Report on Aquaculture Development in the Black Sea*. Report prepared for the first meeting of the *ad hoc* GFCM Working Group on the Black Sea, Constanta, Romania, 16–18 January 2012. GFCM Occasional paper.

Espaldon, M.V.O. 2009. Key concepts and principles in developing indicators for sustainable rural development. *In* M.G. Bondad-Reantaso & M. Prein, eds. *Measuring the contribution of small-scale aquaculture: an assessment,* pp. 29-44. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180 pp.

European Commission. 2012. *Guidance on Aquaculture and Natura 2000. Sustainable aquaculture activities in the context of the Natura 2000 Network.* European Commission. 89 pp.

FAO. 1987. *Site selection for aquaculture: Introduction, technical and non-technical considerations in site selection.* Lectures presented at ARAC for the Senior Aquaculturists course. Project Report AC 170, ARAC/87/WP/12-1&2, 9 pp.

FAO. 1989. *Sustainable development and natural resources management.* Twenty-fifth Conference. C 89/2 – Suppl. 2. August. Rome, FAO. 54 pp.

FAO. 1995. *Code of 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. © 2005-2012. World inventory of fisheries. Conditions for sustainable development. Issues Fact Sheets. **Text by Rebecca Metzner & Serge M. Garcia.** In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 27 May 2005. [Cited 12 April 2012]. http://www.fao.org/fishery/topic/13297/en.

FAO, NACA, UNEP, World Bank & WWF. 2006. *International Principles for Responsible Shrimp Farming.* Bangkok, Thailand, Network of Aquaculture Centres in Asia-Pacific (NACA). 20 pp.

FAO. 2009. *Report of the FAO Workshop on the Development of an Aquatic Biosecurity Framework for Southern Africa.* Lilongwe, Malawi, 22–24 April 2008. FAO Fisheries and Aquaculture Report. No. 906. Rome, FAO. 2009. 55 pp.

FAO. 2010a. *Aquaculture development. 4. Ecosystem approach to aquaculture.* FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. Rome, FAO. 53 pp.

FAO. 2010b. *The State of World Fisheries and Aquaculture 2010.* Rome, FAO. 197 pp.

FAO. 2011. *Technical Guidelines on Aquaculture Certification.* Rome, FAO. 122 pp.

FAO. © 2008–2012. Small-scale fisheries - Web Site. Governance. FI Institutional Websites. In: *FAO Fisheries and Aquaculture* Department [online]. Rome. Updated. [Cited 9 April 2012]. http://www.fao.org/fishery/topic/16622/en.

FEAP. 2006. *Code of Conduct for European Aquaculture.* Federation of European Aquaculture Producers (FEAP). 12 pp.

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

Gabrielsen, P. & Bosch, P. 2003. *Environmental Indicators: Typology and Use in Reporting.* Working paper prepared for the European Environment Agency (EEA). 20 pp.

Garcia, S.M. & Boncoeur, J. 2007. *Allocation and conservation of ocean fishery resources: Connecting rights and responsibilities.* American Fisheries Society Symposium. American Fisheries Society, Bethesda, Maryland, USA. 28 pp.

GESAMP. 1986. *Environmental capacity. An approach to marine pollution prevention.* GESAMP Reports and Studies No. 30. Rome, GESAMP. 49 pp.

GESAMP. 2001. *Planning and management for sustainable coastal aquaculture development.* GESAMP Reports and Studies, No. 68. Rome, GESAMP. 90 pp.

GESAMP. 2012. Environmental Quality Standards - Web Site. In: *The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)* [online]. UK. [Cited 5 February 2012]. http://www.gesamp.org/work-programme/eqs.

GFCM. 2008a. *Report of the workshop on the selection of indicators for the sustainable development of aquaculture in the Mediterranean* (draft), Montpellier, France, 27–28 November 2008. GFCM:CAQ/VI/2008/Inf11. 12 pp.

GFCM. 2008b. *Trends and issues of marine and brackish Mediterranean aquaculture.* Sixth session of the Committee on Aquaculture. Tirana, Albania, 17–19 December 2008. GFCM:CAQVI/2008/2. 5p.

GFCM. 2009a. *Report of the expert meeting on indicators for the sustainable development of aquaculture in the Mediterranean Sea* (draft), Montpellier, France, 24–26 February 2009. 21 pp. (also available at http://151.1.154.86/faosipam/htm/content/Draft_Report_Montpellier_2.pdf).

GFCM. 2009b. *Report of the 11th Session on Information System for the Promotion of Aquaculture in the Mediterranean (SIPAM)*. Trabzon, Turkey, 9–10 December 2009. 19 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).

GFCM. 2010a. R*eport of the workshop on guidelines and application of indicators for sustainable development of aquaculture-InDAM*. Salammbo, Tunisia, 19–20 November 2009. CAQ/CMWG/2010/7. 12 pp.

GFCM. 2010b. R*eport of the workshop on allocated zones for aquaculture (AZA)*. Sevilla, Spain, 18–20 October 2010. GFCM:CAQVII/2011/Inf.12. 12 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).

GFCM. 2011a. *Report of the WGSA-InDAM expert meeting on definition of regional minimum set of indicators for sustainable aquaculture*. St. George's Bay, Malta, 25–26 November 2010. GFCM:CAQVII/2011/Inf.16. 18 pp.

GFCM. 2011b. *Draft report of the WGSA-InDAM: narrative report of the first year of activities,* St. George's Bay, Malta, 25–26 November 2010. 18 pp.

GFCM. 2011c. *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. 218 pp.

GFCM. 2011d. *Trends and issues of marine and brackish Mediterranean aquaculture*. Rome, Italy, 8–10 March 2011. GFCM:CAQVII/2011/2. 9 pp.

GFCM. 2011e. *Site selection and carrying capacity in Mediterranean marine aquaculture: key issues*. Rome, Italy, 9-14 May 2011. GFCM:CAQVII/2011/Dma.9 (Draft). 180 pp.

GFCM. 2011f. *Report of WGSA-InDAM: Regional Workshop in the pilot case studies and guidelines and application of sustainable indicators in aquaculture.* Malaga, Spain, 14–16 November 2011. 22 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).

GFCM. 2011g. *Report of WGSC-SHoCMed Workshop on the definition and environmental monitoring within allowable zone of effect (AZE) of aquaculture activities within the Mediterranean countries,* Malaga, Spain, 16–18 November 2011. 34 pp. (also available at http://151.1.154.86/GfcmWebSite/MeetingsReportsRepository.html).

Groffman, P., Baron, J., Blett, T., Gold, A., Goodman, I., Gunderson, L., Levinson, B., Palmer, M., Paerl, H., Peterson, G., LeRoy Poff, N., Rejeski, D., Reynolds, J., Turner, M., Weathers, K., & Wiens, J. 2006. Ecological thresholds: the key to successful environmental management or an important concept with no practical application? *Ecosystems* 9:1–13.

Hadj Ali Salem, M., Hamza, H.A. & Ben Salem, S. 2011. *Tunisian Pilot Studies Phase II – Final Report, InDAM Project*. GFCM occasional paper.

Hall, S.J., Delaporte, A., Phillips, M.J., Beveridge, M. & O'Keefe, M. 2011. *Blue Frontiers: Managing the Environmental Costs of Aquaculture.* Penang, Malaysia, The WorldFish Center, 103 pp.

Holland, J. & Blackburn, J. 1998. *Whose Voice? Participatory research and policy change.* Intermediate Technology Publications. London.

IOC/UNESCO, IMO, FAO, UNDP. 2011. *A Blueprint for Ocean and Coastal Sustainability.* Paris, IOC/UNESCO. 45 pp.

IPCC. 2007. *Climate Change 2007: Synthesis Report – Contribution of Working Groups I, II, and III to the Fourth Intergovernmental Panel on Climate Change.* (Core Writing Team: R.K. Pauchauri& A. Reisinger, A., eds). Geneva, Switzerland, IPCC. 104 pp.

IUCN. 2007. *Guide for the Sustainable Development of Mediterranean Aquaculture. Interaction between Aquaculture and the Environment*., Gland, Switzerland and Malaga, Spain, IUCN. 107 pp.

IUCN. 2009a. *Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site managemen*t. Gland, Switzerland and Malaga, Spain, IUCN. 303 pp.

IUCN. 2009b. *Guide for the Sustainable Development of Mediterranean Aquaculture 3. Aquaculture Responsible Practices and Certification.* Gland, Switzerland and Malaga, Spain, IUCN. 70 pp.

Johnson, F.A., Williams, B.K., Nichols, J.D., Hines, J.E., Kendall, W.L., Smith, G.W. & Caithamer, D.F. 1993. *Developing an adaptive management strategy for harvesting waterfowl in North America.* Transactions of the North American Wildlife and Natural Resources Conference 58:565–583.

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

Mathé, S. & Rey-Valette, H. 2011. Towards the implementation of sustainable development of aquaculture in the Mediterranean: the conditions of governance. *In* GFCM, 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. 218 pp.

Mathé, S., Rey-Valette, H., Brunel, O., Clément, O., René, F. & Blancheton, J.-P. 2011a. Analysis of the standards and indicators for sustainable development of aquaculture. *In* GFCM, 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. 218 pp.

Mathé, S., Rey-Valette, H. & Chia, E. 2011b. Key issue and some postulates concerning the use of indicators for sustainable development: the example of aquaculture. *In* GFCM, 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. 218 pp.

McKindsey, C.W., Thetmeyer, H., Landry, T. & Silvert, W. 2006. Review of recent carrying capacity models for bivalve culture and recommendations for research and management. *Aquaculture*, 261:451–462.

Monfort, M.C. 2010. *Present market situation and prospects of meager (*Argyrosomus regius*), as an emerging species in Mediterranean aquaculture.* Studies and Reviews. General Fisheries Commission for the Mediterranean. No. 89. Rome, FAO. 28 pp.

Muradian, R. 2001. Ecological Thresholds: a survey. *Ecological Economics* 38:7–24.

NACA. @2001–2012. Certification terms – Web Site. In: *Network of Aquaculture Centres in Asia-Pacific* [online]. Bangkok. [Cited 20 April 2012]. http://www.enaca.org/modules/certificationprojects/index.php?content_id=9.

Noss, R.N. 1990. Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology.* 4:355–364.

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

OECD. 2008. *Handbook on Constructing Composite Indicators – Methodology and User Guide*. Paris, OECD. 162 pp.

Pillay, T.V.R. 1990. *Aquaculture. Principles and Practices.*, Oxford, England, Fishing News Books. 575 pp.

Pinter, L., Hardi, P. & Bartelmus, P. 2005. S*ustainable development indicators: proposals for a way forward. A report prepared for the United Nations Division for Sustainable Development.* Winnipeg, Manitoba, International Institute for Sustainable Development. 43 pp.

Prein, M. 2009. Assessment of aquaculture adoption by small farmers using sustainability indicators, pp. 107-124. *In* M.G. Bondad-Reantaso and M. Prein, eds. *Measuring the contribution of small-scale aquaculture: an assessment*. FAO Fisheries and Aquaculture Technical Paper. No. 534. Rome, FAO. 180 pp.

Rad, F., Yücel Gier, G. & Deniz, H. 2011. *Turkish Pilot Studies Phase II – Final Report, InDAM Project*. GFCM Occasional paper.

Rey-Valette, H., Clément, O., Aubin, J., Mathé, S., Chia, E., Legendre, M., Caruso, D., Mikolasek, O., Blancheton, J.P., Slembrouck, J., Baruthio, A., René, F., Levang, P., Morrissens, P. & Lazard, J. 2008. *Guide to the co-construction of sustainable development indicators in aquaculture.* Montpellier, Cirad, Ifremer, INRA, IRD, Université Montpellier 1. 144 pp.

Schiffman, L.G. & Kanuk, L.L. 2000. *Consumer behaviour.* 7th ed. London, Prentice Hall.

UNEP/MAP-METAP SMAP III. 2009. *The Way Forward for the Mediterranean Coast – A framework for implementing regional ICZM policy at the national and local level.* Final ICZM Policy Report. 48 pp.

UNEP/PAP/RAC. 2008. *Protocol on Integrated Coastal Zone Management in the Mediterranean*. 89 pp.

Walters, C.J. 1986. *Adaptive management of natural resources*. New York, MacMillan. 374 pp.

Zahm, F., Viaux, P., Girardin, P., Vilain, L. & Mouchet, C. 2006. *Farm sustainability assessment using the IDEA Method*. INFASA symposium March 16–17, Zentrum Paul Klee Bern, Switzerland. 20 pp.

Zweig, R.D., Morton, J.D. & Stewart, M.M. 1999. *Source water quality for aquaculture: A guide for assessment.* Washington, D.C, World Bank. 62 pp.

Appendix I

Glossary

This glossary provides an alphabetical list of the meaning of special, unusual, or technical words or expressions used in this Guide.

Term	Definition
Adaptive approach	It is a term that is often associated with management, which focuses on an experience- and feedback-based learning process. Adaptive management strategies, often used in the natural sciences, may also employ intervention to test the response of the system to manipulations (Blackhart *et al.*, 2006; Johnson *et al.*, 1993; Walters, 1986).
Allocated zone for aquaculture	For coastal areas, an allocated zone for aquaculture (AZA) is intended as a spatial planning system or zoning, carried out at local or national level; an AZA is also: (i) a marine area where the development of aquaculture is prior to other uses; (ii) an area dedicated to aquaculture, recognized by physical or spatial planning authorities, which would be considered as a priority for local aquaculture development (GFCM, 2010b).
Allowable zone of effect	An allowable zone of effect (AZE) is an area of seabed or volume of the receiving water body in which a competent authority allows the use of specific environment quality standards (EQS) for aquaculture, without irreversibly compromising basic environmental services provided by the ecosystem (GFCM, 2011g).
Aquaculture	Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans, other invertebrates, crocodiles, alligators, turtles, amphibians and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquaculture production is defined as an increment of biomass and/or an increment in number of individual organisms produced during the period of farming. Therefore, in order to measure aquatic production, both inputs to and outputs from the farming environment are needed. Seed going into a culture-based fishery is considered as an output from aquaculture to fishery, while seed collected by fishery for aquaculture is considered as an input from fishery to aquaculture (GFCM, 2009b).
Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems (Crespi and Coche, 2008).

Bioindicators	Bioindicators (biological indicators) generally refer to certain species or communities that are monitored to assess the quality of the environment and how it changes over time. Changes in the marine environment are often attributed to anthropogenic disturbances (e.g. pollution) or natural stressors (e.g. ocean acidification) that are often monitored by means of macrofauna (Noss, 1990).
Biosecurity	Biosecurity is defined as a strategic and integrated approach that encompasses the policy and regulatory frameworks for analysing and managing relevant risks of the sectors dealing with: human life and health (including food safety); animal life and health (including fish); plant life and health; environment (FAO, 2009).
Better management practices	Better management practices (BMP) are management practices aimed at increasing both the quantity and quality of products taking into consideration food safety, animal health, environmental and socio-economic sustainability. BMP implementation is generally voluntary. The term ”better” is preferred to ”best” because aquaculture practices are continuously improving, i.e. today’s “best” is tomorrow’s “norm” (NACA, 2001-2012).
Carrying capacity	The amount of a given activity that can be accommodated within the environmental capacity of a defined area. In aquaculture it is usually considered to be the maximum quantity of fish that any particular body of water can support over a long period without negative effects to the fish and to the environment (Crespi and Coche, 2008). Carrying capacity is now also being described by the following four definitions commonly applied to both bivalve farming and finfish cage culture: Physical carrying capacity: it is defined as the total area of marine farms that can be accommodated in the available physical space. Production carrying capacity: it is defined as the maximum sustainable yield of cultured organisms that can be produced within an area. Ecological carrying capacity: it is defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, species, populations, or communities in the environment. Social carrying capacity: it is defined as the amount of aquaculture that can be developed without adverse social impacts. (McKindsey *et al.*, 2006; Byron and Costa-Pierce, 2010)
Co-construction approach	The co-construction approach is a joint approach to building indicators which is procedural, adaptive and participatory and aims to promote collective learning in order to implement a sustainable aquaculture (Rey-Valette *et al.*, 2008).

Code of conduct	A code of conduct (CoC) is usually an “overarching document” comprising a set of principles and criteria that may be used as a basis for certification. Examples of CoC include the following: 1. The FAO Code of Conduct for Responsible Fisheries (CCRF), an internationally accepted CoC for fisheries and aquaculture. The FAO CCRF establishes principles and standards applicable to tile conservation, management and development of all fisheries in a non-mandatory manner, and provides a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment Examples of regional and national CoC based on the CCRF: 2. Code of Conduct of the Federation of European Aquaculture Producers 3. Australian aquaculture Code of Conduct 4. Thailand Code of Conduct for shrimp farming (NACA, 2001-2012; FAO, 1995).
Code of practice	A code of practice (CoP) is usually a “lower level” document that provides guidance on management or other practices to be adopted in implementing the principles of the codes of conduct. Some examples are: 1. The Global Aquaculture Alliance (GAA) Codes of Practice for Responsible Shrimp Farming. 2. The International Council for the Exploration of the Sea (ICES) Code of Practice on the Introductions and Transfers of Aquatic Organisms. (NACA, 2001-2012)
Coastal zone	Coastal zone means the geomorphologic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities (UNEP/PAP/RAC, 2008).
Consumer perception	The response of persons when they see a product or a "brand" (a name or symbol that distinguishes the products or services of one seller from others) and their attitudes (not necessarily involving a reaction) regarding the specific product or service (Schiffman and Kanuk, 2000).
Criteria	Within a principles-criteria-indicators methodology, criteria break down each principle into several specific themes or homogeneous elements and specify the issue(s) to be addressed through the relevant variables to be monitored. Criteria should be formulated expressing the degree or state of the variable, e.g. level of…, control of…, existence of …, access to…, capacity of…, as in ”level of input efficiency” (GFCM, 2011c, modified).

Ecosystem	A natural entity (or a system) with distinct structures and relationships that liaise biotic communities (of plants and animals) to each other and to their abiotic environment. The study of an ecosystem provides a methodological basis for complex synthesis between organisms and their environment (GESAMP, 2001).
Ecosystem services	Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services, such as spiritual and cultural benefits; and supporting services, such as nutrient cycling or waste degradation, that maintain the conditions for life on Earth (Alcamo *et al.*, 2003).
Ecosystem approach to aquaculture	An ecosystem approach to aquaculture is a strategy for the integration of an activity within the wider ecosystem so that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems (FAO, 2010a).
Environmental quality standard	An environmental quality standard (EQS) is a value, generally defined by regulation, which specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water (GESAMP, 2012).
Equity	Equity is a principle of stewardship. In fisheries and environmental management, equity relates to fairness, justice, impartiality and freedom from bias or favouritism (e.g. in the allocation of rights or determination of claims). It requires that similar options be available to all parties. It is an important factor of compliance (Garcia and Boncoeur, 2007).
Indicator	Within a principles-criteria-indicators methodology, indicators are a simple way to express the information related to the criteria. They are communication tools identified at farm, local, national and regional level which serve to quantify and simplify information in order to make it understandable to a target audience. Indicators provide benchmarks to assist in monitoring, evaluating, forecasting and decision-making (GFCM, 2011c, modified). An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria (FAO, 1999). Indicators are tools for monitoring, evaluation, forecasting and decision support. They are defined by reference to agreed targets; the confrontation of values taken by an indicator with the corresponding objective allows judging the effectiveness of an action. Indicators are also communication tools that are used to quantify and simplify information to make it understandable to a targeted audience (Madec, 2003). Indicator is a parameter, or a value derived from parameters, which

	points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value (OECD, 2003). An indicator is an observable variable used to report a non-observable reality (Boulanger, 2004). Indicators are not just tools for measuring progress or a specific situation. They are also inventories which enable a variable to be defined, amongst several others. The variables can be arranged in order of importance to form a sort of control panel. But an indicator is also an internal and external communication vector. The indicator becomes a standard once it is accepted and its limitations are identified. It becomes the signal which can eventually entail penalties for situations which, beyond the aforementioned threshold, are considered negative (Chia, 2010).
Integrated coastal zone management	Integrated coastal zone management (ICZM) means a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts (UNEP/PAP/RAC, 2008).
Participatory approach	Participatory approach assigns considerable weight to the opinions and perspectives of residents and local populations (stakeholders) in the decision-making process, regarding a wide range of issues, such as for example aquaculture site selection and management. This is a "bottom-up" process whereby stakeholders are involved in all aspects, e.g. from decisions on how to go about evaluating the potential sites, who carries out the evaluation process and how the site will be monitored. It is a participatory approach because it invites participation of all relevant sectors, and not only the decision-makers (Holland and Blackburn, 1998).
Principle	Principles are associated to the dimensions of sustainable aquaculture. Within a principles-criteria-indicators methodology, they are the high-level goals to address an issue and determine the criteria and indicators to be selected. Principles should be formulated as short statements, with actions verbs originated from management vocabulary such as: contribute, ensure, adapt, strengthen, minimize, etc. For example, “Minimize the impact of aquaculture on the environment” (GFCM, 2011c, modified).

Reference point	For a given indicator, a reference point (or standard) is a specific value against which the data are measured and classified. Reference points indicate the particular state of a broad issue to be monitored. Once an indicator is associated with its reference point, it is possible to assess the particular state of the broad issue to be monitored. The value (whether qualitative or quantitative) of a reference point should be validated by international literature, and/or be agreed upon between experts through common opinion or by driven discussions (for example Delphi), and/or endorsed through a multi-stakeholder consensus.
Sectoral planning	Sectoral planning is the strategic planning for a specific industry or sector, which is generally the responsibility of the government, but should also include participation of the private sector. In order to succeed, the plan should consider issues such as: a) the current status of the sector and the desired situation (aspirations), b) how the desired situation may be attained, c) the resources needed to accomplish the desired status, d) the obstacles that may hinder the plans and e) a contingency plan to deal with the obstacles (Asian Development Bank, 2000).
Site selection	The success of aquaculture projects relies heavily on the proper selection of the site for this activity, regardless of whether the site considered is on land or at sea. In addition to the actual geographic location, consideration must be given to physical, chemical and biological/ecological factors, as well as to the socio-economic aspects of the proposed venture. The optimal situation is where the aquaculture activity is deemed environmentally, socially and economically sustainable. This involves planning with respect to the specific culture systems and the species to be cultivated and requires foresight regarding the impacts of aquaculture on the environment as well as the effects of surrounding activities and the environment on the enterprise (FAO, 1987; IUCN, 2009a).
Stakeholder	Any person or group with a legitimate interest, for instance in the utilization, conservation and management of resources (Crespi and Coche, 2008).
Standard	See reference point.

Sustainable development	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 of continued satisfaction of human needs for present and future generations. Such sustainable development conserves (land) water, plants and (animal) genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable (FAO, 1989).
Sustainable development framework	A sustainable development framework is a structure used to select and organize principles, criteria, indicators and reference points. It is based on a particular set of dimensions of sustainability (FAO, 1999, modified).
Thresholds for environmental change	In an ecological, economic or other system, thresholds are the critical values beyond which the system goes through a substantial change. Small changes in crucial variables (e.g. a slight rise in seawater temperature) can lead to large responses in the system (e.g. large drop in reproductive success of a keystone marine species) (Muradian, 2001; Groffman *et al.*, 2006).

Appendix II

Regional indicators for Mediterranean and Black Sea aquaculture

This appendix provides the list of regional indicators defined as minimum common number of indicators that could be applicable in each country within the GFCM region.

Economic dimension

Principle	Criteria	N°	Indicator	Reference values
Strengthen financial management of enterprises	Level of profitability	**1**	**Production value index (PVI)**	See trend in value, ±
		2	**Input/output price parity**	See trend in parity, ±
Strengthen consumer-responsive and market-oriented aquaculture	Use of branding or quality assurance schemes/labels	**3**	**Use of quality certification schemes by independent bodies for target markets**	See trend in percentage of enterprises having quality certification scheme/s
Strengthen risk assessment and crisis management capabilities	Level of diversification	**4**	**Number of products**	See trend in no. of cultured species, size categories and other differentiated or value added products, ±
	Level of collective marketing and actions	**5**	**Existence of collective actions (collective marketing, market promotion) by farmers' organizations**	See trend in: - Number of promotional activities and/or -Volume of products marketed through collective marketing; ±

Environmental dimension

Principle	Criteria	N°	Indicator	Reference values
Minimize the global impact of aquaculture	Needs of natural resources for food production (pelagic fish and plants)	**1**	**FCR feed conversion ratio (kg food/kg fish)***	Seabass (350-400 gr): > 2.2/2.2-1.8/<1.8 Seabream (300-350 gr): >2.1/2.1-1.6/<1.6
Maintain the ecological services of ecosystems	Reduction of benthic environmental impact	**2**	**Existence of criteria for the depth (m) of cage applied to site selection. Related to density. Ratio of depth and density (depth (m)/ density (kg/m3)**	< 1.5 / 1.5 –2 / >2**
Minimize the local impact on environmental conditions and biodiversity	Use of chemical products	**3**	**Existence of a national monitoring programme to monitor antibiotics and other chemical residues**	Yes/No
	Impact on benthic habitats and communities	**4**	**Implementation of a monitoring system for the evaluation of the level of impact on benthos**	Yes/No
	Biological impact on communities	**5**	**Reporting of escapees (number of escape events)**	Number of escape events

Note: * = The FCR Ref. Values vary according to the farmed species
** = Higher fish density results in increased organic matter sedimentation, and higher depth would increase the dispersion

Social dimension

Principle	Criteria	No	Indicator	Reference values
Contribute to food security and food safety	Importance of fish availability and supply. Contribution to food security.	**1**	**Relevance of fish produced for domestic markets**	Consumption of national products (kg per capita) related to consumption of foreign products (kg per capita)
	Transparency of production and trading process (from farm to the table).	**2**	**Existence of mechanisms of information with regard to the aquaculture production process and its compliance to regulations available and accessible to the public**	Existence and implementation of labels according to food safety and traceability regulations
Strengthen the role of farmers' organizations and NGO's to improve image of aquaculture, social awareness and responsibilities	Importance of fish farmer organizations	**3**	**Existence of strategies or initiatives developed by farmers' organizations towards the improvement of aquaculture image**	Percentage of the total budget of the farmers' organizations dedicated to aquaculture promotion and image building
Strengthen corporate social responsibility	Quality of labour conditions	**4**	**Existence of national legislation on employees' welfare fully applied by the aquaculture sector**	Yes/No

Governance

Principle	Criteria	No	Indicator	Reference values
Strengthen integration of aquaculture in local development	Importance of development initiatives	**1**	**Existence of allocated zones for aquaculture (AZA) – (%) (number of farms in AZA/total number of farms *100)**	0-25% Red; 25-75% Yellow; 75-100 Green
Promote participatory decision-making process	Level of stakeholders' participation	**2**	**Existence of participatory mechanisms in decision-making processes**	Yes/No
Strengthen research, information systems and extension service	Importance of research and training in aquaculture	**3**	**Existence of funded research and development (R&D) programmes and training on aquaculture development**	Yes/No
Strengthen institutional capacities	Level of recognition of sustainable development	**4**	**Existence of specific legislation governing aquaculture development in line with the principles of the CCRF**	Yes/No
Aquaculture monitoring and reporting mechanism	Capacity of monitoring and reporting on aquaculture development	**5**	**Existence of data collection and dissemination systems**	Yes/No

This publication provides guidance for the use of indicators to monitor the sustainable development of aquaculture in Mediterranean and Black Sea countries. It mainly draws upon the outcomes of the activities carried out within the InDAM project on "Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean", funded by the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE), as well as the outputs of other projects and initiatives dealing with Mediterranean aquaculture sustainability. InDAM has been carried out in support to the Working Group on Sustainability in Aquaculture (WGSA) of the GFCM Committee on Aquaculture (CAQ). The publication was prepared by the GFCM Secretariat in close collaboration with coordinators and experts of the WGSA, the Working Group on Marketing on Aquaculture (WGMA), the Working Group on Site Selection and Carrying Capacity (WGSC), the Information System for the Promotion of Aquaculture (SIPAM), as well as other experts involved in projects and research activities on indicators for sustainable aquaculture and key stakeholders.

ISBN 978-92-5-107483-1 ISSN 1020-9549

9 789251 074831

I3194E/1/01.13