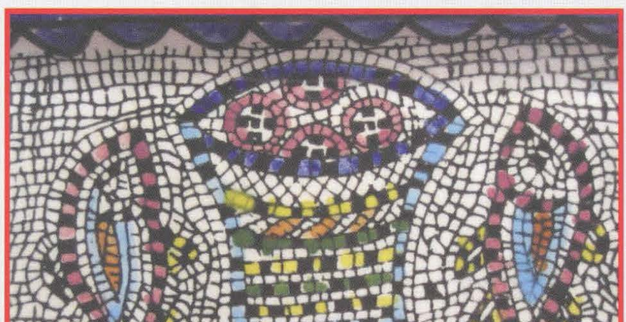
GUIDE TO THE CO-CONSTRUCTION OF SUSTAINABLE DEVELOPMENT INDICATORS IN AQUACULTURE



EVAD

GUIDE TO THE CO-CONSTRUCTION OF SUSTAINABLE DEVELOPMENT INDICATORS IN AQUACULTURE

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This *Guide to the co-construction of sustainable development indicators in aquaculture* builds on the achievements of the EVAD research project - Evaluation of aquaculture system sustainability - undertaken between 2005 and 2008 by five French institutes (Cirad, Ifremer, INRA, IRD and University of Montpellier 1) together with their partners in five areas within the framework of the federating programme in Agriculture and Sustainable Development of the National Research Agency.
Co-coordinator: Jérôme Lazard (Cirad)

Authors
Hélène Rey-Valette (UM1), Olivier Clément (INRA), Joël Aubin (INRA), Syndhia Mathé (UM1), Eduardo Chia (Cirad), Marc Legendre (IRD), Domenico Caruso (IRD), Olivier Mikolasek (Cirad), Jean-Paul Blancheton (Ifremer), Jacques Slembrouck (IRD), Aurèle Baruthio (Cirad), François René (Ifremer), Patrice Levang (IRD), Pierre Morissens (Cirard) and Jérôme Lazard (Cirad)

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TA B-20/01- 34398 Montpellier cedex 5 - France
e-mail: jerome.lazard@cirad.fr
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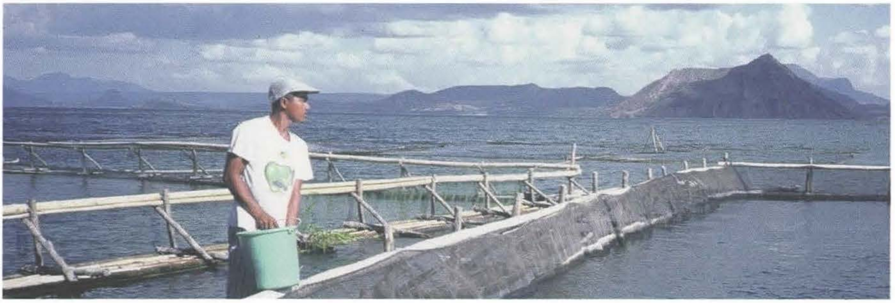


Guide to the co-construction of sustainable development indicators in aquaculture

CONTENTS

Foreword

This guide is one of the outputs of a research study* carried out in several aquaculture regions in the following countries: Cameroon, Cyprus, Indonesia, France and the Philippines. This study brought together various aquaculture specialists, researchers in human sciences and many local actors.

You will find in the following pages:

- the exposition of a thorough and pragmatic approach strongly anchored in sustainable development using defined stages;
- various boxes: recommendations concerning surveys, itinerary examples, various illustrations;
- examples of sustainability diagnoses undertaken in the field;
- a comprehensive principles, criteria and indicators reference baseline;
- an extensive bibliography.

By reading the guide chronologically, the theoretical hypotheses underpinning the choice of the approach can be understood and the classic implementation stages of the approach can be followed step by step. However, it is quite possible to advance sequentially, extracting useful information, diagrams and lists according to specific needs when one is already involved in an effort to build or evaluate sustainable development. For such usage, it is helpful to refer to pages 11 and 12 which set out the 7 chapters with their content and contribution to the approach.

* *EVAD Project within the framework of the Agriculture and Sustainable Development federating programme of the National Agency for Research. 2005-2008*
EVAD = Evaluation of aquaculture system sustainability

Introduction

1. New challenges for aquaculture

Considered marginal compared with fisheries until the 1970s (except in China), aquaculture started to develop rapidly from the 1980s. With 66.750 million tonnes produced in 2006 (FAO, 2006), it now represents half of the aquatic resource production destined for human consumption (120 million tonnes) and tends to compete with fisheries production. Concentrated in a few countries, essentially in Asia (China represents 70% of global aquaculture production), most of the production comes from the extensive and semi-intensive lagoon farming of fresh water species (Chinese and Indian carps, tilapias,…) or of fast-growing catfishes such as Pangasiidae (mainly in South-East Asia and Vietnam). Other production concerns molluscs and a few flagship species such as salmonids (Norway, Chile), prawns in the inter-tropical zone or the sea-bass and the sea-bream in the Mediterranean… Overall, aquaculture concerns more than 240 species of which 25 account for 87% of the production.

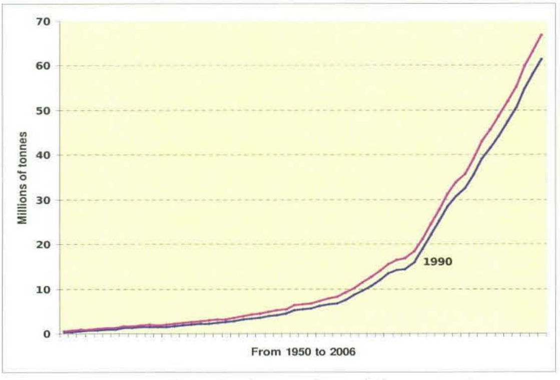


Figure 1. Asian (blue) share of world aquaculture production (pink) *(FAO, 2006)*

Initially, aquaculture created the hope of a technological, nutritional and economic blue revolution. The negative impacts of farming systems and their poorly-controlled intensification process on the environment and on local populations have tarnished its image and led to several crises. Nonetheless, aquaculture development has also led to multiple innovations and adaptations, allowing it to overcome site and market constraints and move towards farming practices that are more environmentally friendly, more mindful of social impacts and better integrated.

Aquaculture now faces two major challenges.

(1) Satisfy the growing global demand for aquatic products.
Stagnating capture fish production and, more recently the crisis in many fisheries, within a context of growing nutritional needs, have increased the demand for aquaculture products. The contribution of aquaculture to the global market for aquatic products has risen from 9% in 1980 to 50% today, and it is increasingly seen as a solution to meet the demand for food.

(2) Develop towards sustainability.
The geographical distribution of aquatic products, currently the leading traded agricultural product of animal origin on the world market (40%), will have to adapt to the increasing control of CO_2 emission impact and to declining fossil fuel energy resources.
Local species will increasingly be identified as those that will benefit most from research carried out on their domestication. Technical systems will have to take into account, and even add value to, the services provided by exploited ecosystems whilst the exploitation systems will focus on sustainable development

Meeting these challenges should lead to the diversification of both production and the means of production as suggested by the think-tank on the future of the French aquaculture sector towards the year 2021 (Inra, 2007), where five contrasting scenarii were identified:

- a rural aquaculture involved in local development,
- an industrial aquaculture increasingly dependent on markets and globalisation,
- a highly innovative aquaculture of neo-producers developing niche-markets or filling new gaps for neo-consumers,
- an aquaculture focused on quality and proximity, supported by small pro-active companies and certification processes (ecolabels in particular)
- and a more pessimistic scenario where the long-term future of aquaculture is threatened by the number of constraints, concerning in particular site access and increasingly demanding standards

Faced with such challenges, it is essential to assist and facilitate the development and/or the evolution of the sector towards more sustainable aquaculture systems.

2. Why propose a guide for a co-construction approach?

The aim of this guide is to suggest an original and operational approach based on the observation that sustainable development, due to the significant changes that it implies in the mentality and the practices of the actors, requires a special kind of support in order to be appropriate and applicable. Building indicators for the sustainable development of aquaculture must be perceived not simply as setting up a monitoring system but as an opportunity to define the challenges of sustainable aquaculture development collectively and at various scales. Lessons must be drawn from the many efforts to build sustainable development indicators, often unsuccessfully and resulting, both in aquaculture and in other areas, in "graveyards" of indicators and observatories. The postulate underlying the present approach is that a good indicator is an indicator that is used. Hence, when building indicators their use must be kept in mind. But in order to be used, they must make sense to the actors, which implies that the latter are involved in and discuss not only the indicators or the monitoring variables but also the objectives guiding the implementation of sustainable development.

Hence, this guide is different from other handbooks, guides or protocols insofar as the approach it recommends is a joint approach to building indicators which is procedural, adaptive and participatory. It aims to promote collective learning in order to implement a sustainable aquaculture. This approach implies three conditions:

1. to take into consideration the representations of the fish-farmers and the stakeholders. This means that the target values and the objectives must be clear and that there must be no sudden break with existing practices and representations when introducing the new sustainable development framework.

2. to consider that the joint approach to the building process is an opportunity for reciprocal openness and learning, thus creating the conditions for discussion, negotiation, formalisation and institutionalisation of the indicators (monitoring arrangements).

3. to work in an area where there are no major conflicts so that the joint approach to the building process can progress without significant obstacles.

Box 1
Details on the notion of "procedural"

Procedural means to follow a procedure. Simon (1992) defined the notion of procedural rationality to illustrate the decision-making process of individuals in a state of uncertainty. He showed that it is the decision-making process rather than the objectives or the methods which is the determining factor. This notion is also used in the fields of public policies and of collective decision-making processes to explain a construction or a decision which is iterative in the sense that it is built from cumulative contributions. This iterative nature introduces a further degree of progression which strengthens the participatory and adaptive aspects. This notion of "procedural" as opposed to normative, can also convey political styles, particularly in the field of environment with the contrasting normative French model and the procedural English model which is much more widely based on legal precedents (Szarka, 1999).

3. An accompanying approach with multiple objectives and methods

The guide is a tool which is intended to help build sustainable aquaculture development indicators, it gives:

- practical recommendations on implementation methods, which will favour a joint approach to the building process,
- a generic foundation of principles, criteria and indicators established from a wide diversity of aquaculture systems and countries. It allows appropriate indicators to be chosen by defining combinations and associations that are adapted to each situation. Furthermore, in order to facilitate larger-scale comparisons, this reference list was established by seeking, so far as possible, matches with other sustainable aquaculture reference frameworks like Consensus (EAS, 2005), IDAqua (CIPA/ITAVI, 2007) or IUCN (2005) (Mathé et al., 2006).

The approach suggested here can be an alternative or complementary to the traditional regulatory pathways such as interventions by public institutions or market-based regulation, in particular through certification or labelling approaches. It must be borne in mind that the risks and constraints usually condemned in public interventions are the avoidance or non-application of the measures whilst certification or labelling approaches lead in fine to the hegemony of certain standards with potentially large unequal impacts.

Box 2
Certification, standards and ecolabels

The conflicts created by the impact of prawn farming around the 1990s pushed the actors who were directly involved, the producers and the traders to improve aquaculture practices. Various initiatives were born with the support of FAO, IUCN, NACA or the World Bank in order to move aquaculture into the sustainable development era. Originally centred on prawns, these initiatives have gradually included the main species involved in commercial trade: Atlantic salmon, pangasius, tilapia, rainbow trout. From this development, **standards** emerged establishing the conditions for choosing each type of aquaculture from site selection to the consumer's plate via best practice in production. Among the better known are those of the GAA, Global Aquaculture Alliance or those of GLOBALGAP. Very quickly, the instigators of standards were led to develop procedures to ensure that the production process complied with the selected conditions: hence, they developed **certification**. Some

Box 2
Certification, standards and ecolabels

thirty certification schemes were identified in 2007 in an inventory (WWF, 2007). In an optimum situation, third party organisations carry out the evaluations and issue the certificates. If the latter can be attached to the products and therefore be read by the consumer, they are referred to as **ecolabels**. More recently, the WWF has opened a "dialogue" with the stakeholders, in particular, the hyper and supermarkets in order to clarify in writing the common ground that exists for some twelve species. At an international level, this initiative brings together representatives from the aquaculture industry, governmental agencies and the research community. Typically, it involves a top-down approach and the resulting decisions will be included in the reference frameworks for any local and regional joint approach.

In its very design, the suggested approach seeks to combine the advantages of "top down" approaches, through the common points found in the reference framework, with those properties of participatory approaches covered by "bottom up" approaches.

4. A guide designed for a group of operators and/or an institutional organisation

From the moment a joint approach is considered, the participants must be identified and the methods used to organise the dialogue must be specified. It should be stressed that as a collective approach, the joint approach follows the same principles as any collective approach, i.e. it must involve the partners as early as possible to gain their support and it must seek optimally-sized working groups in order to promote a dialogue. Two complementary scales of the approach influence the range of partnerships: aquaculture farms (and their value chain) or aquaculture zones which are the areas where these enterprises operate.

The initiative for the joint approach can originate from either a group of operators, a research centre or an institutional organisation. The latter may be part of the aquaculture sector (trade union, administration) or of an area where aquaculture is present (local authority, interagency group…). In any case, it is necessary to form a group which will pioneer the approach and to identify a broad-based set of stakeholders from the aquaculture system(s) concerned in order to avoid being restricted to immediate actors only, in particular from the sector. In fact, even though the sustainable development framework is designed to be applied at a limited scale, if it is discussed with a wider range of stakeholders, it will take into account a greater spectrum of viewpoints and become more consensual. Table 1 shows the hierarchy of links and participatory levels within a joint approach to the building process. Further details on the composition of these different spheres of activity are given in the description of the inception phase of the approach (cf. part 4).

Table 1. Characterisation of the degree of involvement of the actors.

Group pioneering the approach	Stakeholders involved	Surveyed actors
Run the approach supported by a partnership relationship between the group members	Take part in selection and validation working groups	Only take part in surveys

5. Structure of and directions for using the guide

The guide begins by setting out the four postulates underlying the approach (**1st part**). These summarise some key points arising from the evaluation of many sustainable development initiatives and are illustrated by examples drawn from experiments that have been carried out. This part, although more conceptual, is essential to understand the logic underlying the approach and facilitate any potential adaptation. It contributes significantly to the collective learning process by allowing the sharing of common knowledge on the use of indicators and the necessary conditions for sustainable development. The **second part** deals with the reference framework which supports the approach, i.e. the nesting of principles, criteria and indicators. Such nesting makes it possible to link the indicators to the issues at stake for, and the representations of, the actors, thereby enhancing the appropriation and use of the indicators that are developed.

The directions for using the approach are explained in the **third part** which details three major implementation phases (preparation, selection and validation), each of which comprises several stages alternating between implementation by the pioneering group and a dialogue-based joint effort to build indicators. Following this overview, the next part (**4th part**) presents in detail the stages for each of these three phases. The suggested recommendations and guidance have deliberately been left as flexible as possible so that the users of the guide can adjust the involvement and the range of stakeholders and adapt the approach to their objectives and to the context within which it is to be implemented.

The **fifth part** then introduces the sustainability principles and criteria which make up the reference framework upon which the users can draw to establish their own list according to their needs. This reference framework is accompanied by an indicative list of indicators. It is annexed to the text to make for easier reading. Having specified the methods used to assess and to present the results (**6th part**), the last part of the guide (**7th part**) gives the examples of two experiments that have been carried out: in France (Brittany) for trout culture and in Indonesia for cage aquaculture on the Cirata Reservoir.

Throughout the guide, boxes complement the main text, stressing key issues or explaining the recommendations in a more theoretical light. Finally, various appendices give examples or technical documents to facilitate use of the guide.

It should be borne in mind that the whole guide is meant to be a kind of route map and should be read as an organised succession of reference points leading towards a joint approach to building indicators for sustainable aquaculture development.

EVAD

Chapitre 1
The postulates underlying the adaptive and participatory nature of the approach

In order to ensure that the approach presented in this guide is operational, it is based on work relating to the use of indicators and more generally on research carried out in the fields of innovation, learning and management of organisations. It was developed within the framework of a research project (box 3) which made it possible to test its application on several very diverse aquaculture systems. These systems were chosen according to a structuring matrix which correlated several factors in order to encompass a wide variety of environments (inland and marine aquaculture systems), of intensification levels in production systems (pond, lagoon, cage), of regulatory systems and of institutional backgrounds. In all, six aquaculture systems were analysed: rainbow trout in ponds in the Brittany region (France), bass and sea-bream in cages in the Mediterranean (French Mediterranean and Cyprus), the extensive polyculture of prawns and fish in brackish lagoons in Pampanga (Philippines), tilapia and carp in floating cages in the Cirata dam reservoir (Indonesia), the village-based aquaculture of catfish in lagoons in central Sumatra (Indonesia) and rural tilapia and catfish polyculture in the Western Province of Cameroon.

The EVAD project (Evaluation of the sustainability of aquaculture production systems) was undertaken and funded within the framework of the "Programme Fédérateur Agriculture et Développement Durable" (Federating programme in agriculture and sustainable development) of the "Agence Nationale de la Recherche" (ADD-ANR) (Agriculture and Sustainable Development - National Research Agency (ADD-NRA). Its objective was to establish a generic method to analyse the sustainability of aquaculture that could be adapted to the different types and scales of aquaculture systems. It included five research institutes (Cirad, Ifremer,

Box 3
Presentation of the EVAD project
1/2

Box 3
Presentation of
the EVAD project
2/2

Inra, IRD and Montpellier University 1) and involved a multidisciplinary team of some fifteen researchers (zootechnicians, biologists, economists, managers). Various professional and institutional partners took part in the project within the framework of the experiments undertaken in the six study sites. In all, five partners were included. They were (in alphabetical order by country) the "Institut de recherche agricole pour le développement" (IRAD) (Institute of agricultural research for development) and the NGO CIFORD (Centre d'Information, de Formation et de Recherche pour le Développement) involved within the framework of the "Pôle de Compétence en Partenariat PCP Grand Sud" for Cameroon, the "Comité Interprofessionnel des Produits de l'Aquaculture "(CIPA) (the Interprofessional Committee for Aquaculture Produce) and the "Institut Technique de l'Aviculture et de l'élevage des petits animaux" (ITAVI) (the Technical Institute for Aviculture and small animal husbandry) for France and the Directorate General for Aquaculture (DGA) for Indonesia and the Council for Aquatic and Marine Research and Development (PCAMRD) for the Philippines. For further details on the results of the EVAD project, it is possible to access all the related reports and publications on the INRA site for aquaculture coordination.
http://www.inra.fr/coordination_piscicole/groupes_de_travail/systeme_d_elevage/evad

The approach is therefore presented as a guide which has been deliberately designed to be as flexible as possible in order to facilitate its use. It is in fact a kind of route map suggesting some co-ordinates as obligatory control points whilst leaving some freedom as to possible routes between these points and a wide choice of principles, criteria and indicators. It should be noted that the generic framework in no way constitutes a "ready to use" list but rather a reference framework where the most relevant principles, criteria and indicators can be selected according to the challenges, the areas and the types of aquaculture concerned.

This type of approach is faithful to the spirit of sustainable development, the implementation of which is intended to be adaptive and concerted. In this context, it is worth noting the principles underlying the evaluation of development as stated in the Bellagio declaration (table 2). The recommended "local-global" linkage rejects any fractal or homothetic method of operation (box 4) preferring the local application of the common principles established by the Rio convention in 1992. This local focus in response to specific challenges is favoured over an automatic application regardless of the place and over the use of fixed standards whether international, national or related to the certification approach.

Table 2. "Bellagio principles" applicable to any sustainable development evaluation process (which are classified here according to the evaluation stage)
http://www.iisd.org/measure/principles/progress/bellagio_full_fr.asp

Reference situation	Principle 1. To have a clear vision of sustainable development and goals that define that vision
Content of the evaluation	Principle 2. To adopt a global outlook Principle 3. To deal with the fundamental dimensions and challenges of sustainable development Principle 4. To take account of progress made in a long-term perspective and at different scales Principle 5. To define a structural framework for the evaluation which is operational and centered on a few key elements and indicators
Implementation	Principle 6. To clarify the methodology, the hypotheses and the risks Principle 7. To meet policy-makers' requirements and be easily understandable Principle 8. To be carried out in collaboration with policy-makers and to promote stakeholder participation
Ongoing monitoring system	Principle 9. To be iterative, flexible and adaptable Principle 10. To promote collective learning and to ensure that the process is institutionalised and sustainable in the long-term

As defined by Mandelbrot (1995), the notion of "fractal" refers to the homothetic character of an object which implies a cascading structure where there is a strict repetition of exactly the same configuration. Each part is deduced from the whole by homothetic transformation. Sustainable development, by its very nature, is the opposite of this approach. Instead, it is based on a nesting approach "think globally, act locally" which means that the general principles (defined by the articles of the 1992 Rio convention) are the only common ground and their interpretation according to scales and contexts leads to multiple configurations and arrangements. The principles are adapted according to the specific needs of the context and to the scale of application so as to facilitate their ownership. Hence, each country or region defines a national or regional strategy for sustainable development according to their identified priorities. Then the effective implementation and integration of sustainable development are carried out within the framework of a local agenda 21 where these national and/or regional guidelines are themselves reorganised in a concerted way according to the precise context and needs. This type of approach reveals a change in paradigm emphasizing variety which allows for "a wide range of responses" (Simoulin, 2007). These

Box 4
The non-fractal character of sustainable development
1/2

Box 4
The non-fractal character of sustainable development
2/2

responses can then converge thanks to a specific and progressive process based on mimicking and sharing knowledge, in particular through the dissemination of best practice guides.

POSTULATE n°1. An indicator is not just a measuring tool

The driving force of the approach suggested here is to integrate the multiple functions of the indicators which are the key tools of any evaluation approach in sustainable development. These indicators give the situation (state) or the trend of a variable. Hence, they are traditionally considered as a measuring tool. However, looking at the definition of an indicator shows that all indicators also fulfil an inventory function, highlighting the variable, amongst other possibilities, that must be monitored. It establishes priorities between variables and identifies "models" or "representations" of the important factors to be taken into consideration. The history of statistical systems (such as the development of national accounts) is a reminder that the choice of indicators is the result of negotiations between actors. The fact that these indicators can become promotional tools in the hands of certain lobbies through strategic communication approaches should also be noted. Once selected, an indicator becomes the standard which symbolically determines positive and negative situations thereby designating "the guilty" and "the innocent". It then becomes the signal that may lead to penalties for situations which, beyond some threshold, are considered negative.

Taken together these functions imply that an indicator system may be considered not only as a technical but also as a social arrangement, which reflects a social structure and a compromise at a given time. If the diversity of the indicators' functions is taken into account:

- controversies between actors around the standard that these indicators define can be better understood and managed,
- opportunities to re-discuss and further agree on standards can be taken,
- multiple constraints related to information, whether its access or presentation, that determine their dissemination and their use can be integrated.

Examples

In several experimental sites of the EVAD project (box 3), the implementation of water quality indicators was the subject of controversy between producers, who feel their practices are under suspicion, and the other actors, in particular the administration responsible for the management of conflicts surrounding water resource.
In some cases, the actual definition of the indicator poses a problem: for example, the producers suggest that the water concentration in heavy metals should be monitored, a variable which is highly symbolic for consumers, whilst scientists are of the opinion that this variable is irrelevant as farmed fish are fed totally exogenously on quality compound feed. Likewise, it is usually the producers who tend to highlight the number of jobs created by their activity.

POSTULATE n°2. As implementing sustainable development is an innovative process, it is based on organisational learning and a specific joint approach

The implementation of sustainable development implies profound changes in production and consumption methods, in ways of thinking and in the objectives to be achieved. A new way of representing society is being developed and therefore a new frame of reference must be adopted. Innovations originate from learning processes which differ according to the nature of these innovations. Agryris and Schön (1996) in their book on organisational learning distinguish between simple changes related to practices or actions (single loop learning) and those which involve changes to the fundamental rules and norms underlying action and behaviour (double loop learning). This distinction is useful to highlight the specific pace and needs of the double loop learning process. The changes in values brought about by sustainable development imply a development of "métiers" which concerns not only the way of working but also the objectives and the image of the activity.
For the indicators of sustainable aquaculture development produced by the approach to be adopted and used by the actors, the working methods and the forms of relationships between actors must be adapted to take into account the significant changes introduced by sustainable development. These changes also imply new coordination arrangements and a wider range of stakeholders. It is therefore important to promote openness and participation as a broader range of stakeholders increases the multiplicity of representations and, in order to facilitate their convergence, requires that the implicit reference frameworks adopted by the actors be transparent. This process may be a strategic opportunity facilitating

change in the relationships between actors and their relative strengths (see postulate n°4).

Examples

Generally speaking, professionals who are already committed to quality schemes such as AFNOR or ISO are more likely to think of indicators as norms and therefore to extend this type of approach to new variables expressing sustainability. Small-scale operations are more suspicious of norms and have a more inward-looking approach seeking primarily to use indicators as internal management tools for their farming. Broadening the debate to all the dimensions of sustainable development (environmental, economic, social and institutional) has always been a new approach for producers who have often limited sustainable development to its environmental dimension. The inclusion of the social and institutional dimensions is often a novelty and requires clarification and examples. In Southern countries, professionals are more aware of these aspects but are used to approach them separately through specific programmes (for example the poverty reduction programme).

Implementation of the EVAD project has shown the importance of collective debate. Producers always interpret principles, criteria and indicators according to the level of impact they think sustainable development will have on their enterprise; they are unable to judge for the whole industry. In some cases, such as in Cameroon where accessing information is difficult, or in other countries where there are constraints related to burdensome administrative procedures in terms of openness and dialogue, a keen interest for the EVAD project was noted on account of the collective meetings it generated.

POSTULATE n°3. The joint approach to building indicators promotes organisational learning and helps dialogue

It should be recalled that the distinctive innovative nature of sustainable development as a new mode of production implies a learning process to build a new related reference framework and related norms. This learning process requires a reflexivity process between actors. By reflexivity, we mean here the fact that actors learn from the action from the moment that they are able to view it in perspective and draw some lessons. These conditions require the organised participation of actors, for example through a joint approach. Many evaluations of sustainable development indicators stress the role of dialogue support and of mediation in the collective development of these indicators. In some cases, this property is in fact the main objective being sought. Indeed, the technical debate about the criteria for, and indicators of, sustainability naturally leads to in-depth discussions about the objectives and the content of sustainable development. The joint approach to building indicators can then constitute a "*deliberative and participatory construction*" system (Rudlof, 2006) where the lists of indicators are not only end-products of information systems but also "intermediate objects" (box 5) used to define a reference framework and a common project for sustainable development, in the sense that they are progressively created and that they promote dialogue.

This notion originates from work on the sociology of science and innovation. It conveys the idea of a collective process in building objects which promotes the learning process within a group. The main function of an intermediate object is thus to facilitate exchanges between actors and to shape the dynamics of the collective action. Hence, a table, a list of indicators, a plan, a map, a diagram might, during the co-construction process, constitute intermediate objects as they can be used to specify and define objectives or rules for the group, i.e. they can help to "create sense ". In this way, an intermediate object may be a significant component within a management or governance mechanism.

Box 5
Details on the notion of intermediate object (Vinck 2000)

Any co-construction to building indicators implies a break from the "expert opinion" approach, where science defines the lines of action or from the hierarchical approach, where "institutional authorities" impose a procedure. On the contrary, the aim is to implement an approach based on the sharing of information, knowledge and points of view. The joint approach to building indicators for sustainable development is a shared approach based on several conditions:

- to create a discussion mechanism bringing together several categories of key actors (researchers, producers and producer groups, administrators - managers, NGOs, associations, consumers and other resource users);
- to include the "future" users of indicators as much as possible and more generally the stakeholders in various ways (depending on the phase) in order to compare different opinions according to the type of actor or the different scales (national, regional or local);
- to organise the dialogue phases using various methods (surveys, interviews, focus groups, role-play, participatory multicriteria techniques, etc.) in order to create favourable conditions for dialogue and mutual learning.

Hence, the co-construction process suggested in this guide is a tool to coordinate and accompany the approach and to share information and knowledge relating to sustainable development. It builds more generally on processes of action research, research in partnership or collaborative research which lead to a wide range of implementation methods. The most elaborate form of co-construction approach implies a shared vision of issues resulting from a discussion and mediation process between the actors.

Examples

Even though at the beginning of the EVAD project, the implications of sustainable development were a little vague for most professionals, bilateral and collective discussions aimed respectively at prioritising principles and criteria and at validating the resulting output were an opportunity to address the implications of sustainable development and understand what it meant, individually and collectively.
In the same way, understanding of the multiple roles that indicators might play was created by the project. Hence professionals, although initially inclined to retain many indicators in order to refine the diagnosis, finally went along with the idea of restricting their numbers in order to ensure external understanding and the perennial quality of the approach. However, the project also highlighted the need to specify the measuring scales according to situations. For instance, given that the feed conversion ratio is related to the size of the farmed fish, it is necessary to use differentiated scales depending on whether the farming target is a fish portion or a larger-sized fish.

The EVAD project emphasised the institutional dimension and this has increased awareness of the fact that policy decentralisation may generate new negotiation levels and new ways to express professional representations. By underlining the various representations and opinions, the project gives legitimacy to the notion of compromise which used to be seen as a sign of weakness or a risk of misappropriation or even corruption in some countries. This was confirmed by producers who stated that indicators should "speak to everyone" and that priorities between indicators obviously varied from one actor to another. In some areas, the EVAD project has made genuine dialogue possible in meetings where, to begin with, behaviour was very scholastic and discussions tended to be monopolised by a few "dominant" actors.

EVAD

POSTULATE n°4. The co-construction approach is an opportunity and often generates organisational innovation

The joint approach to building a system of sustainable development indicators is a way to create new standards in a decentralised way within a group of actors. It is no longer the optimum which is sought but a compromise and this is reached by a dynamic process of progressive adjustment. This type of approach where practices which are considered to be positive or innovative are institutionalised is more likely to suit the diversity of actors' values (Cheron and Ermisse, 2008). They then have an opportunity to air their specificities and their constraints and improve the design of the standard. This also provides an opportunity to develop the image of the profession, for example by suggesting codes of behaviour and good practice (box 6). Such a pro-active approach to sustainable development can also help to place the industry within more global approaches to sustainable development implementation, such as national sectoral approaches, international ecolabels or local agenda 21

Box 6
Example of code of conduct of the FEAP

In 1999, the European Federation of Aquaculture Producers took the initiative to produce a code of conduct for aquaculture in the context of the European Union. After more than a year peppered with numerous exchanges and multiple meetings and eight versions of the text, agreement was reached on a final version. This process typifies a patient and negotiated co-construction approach between the representatives of the industry groups which are members of the federation. According to observers, this text helped to strengthen the federation and propelled it to become a now unavoidable interlocutor of the EU General Directorates even though aquaculture used to be a very poor relation in the various plans applied to marine fisheries. More generally, a code of conduct lists principles and outlines a reference framework. It remains indicative and based only on voluntary commitment. It can also be complemented by one or more practical guides which are field applications that are more detailed and based on good practice or on norms. Today and following on from the Consensus Project (2005-2008), the FEAP is planning a new version of its Code of Conduct which would include the 68 indicators of sustainable aquaculture.

However, the implementation of these positive outlooks depends on the evolution of governance systems. Hence, the proximity between actors which has developed progressively during the joint process can be institutionalised within a system or an institution (organisational and institutional innovation). However, in order to achieve this it is necessary that:

- the pioneering group have legitimacy with respect to the entire group of actors as well as the appropriate skills and resources,
- the professional organisations, whether associations or regional in nature, must have sufficient institutional capacity (notion of "empowerment").

The fact that the suggested approach takes into account not only the sustainability of aquaculture systems but also the evaluation of their contribution to local sustainable development is of interest in several ways. It provides producers and professional groups with pro-active approaches as well as the means for dialogue with local managers. Moreover, it also provides a means to communicate about the positive outcomes of the activity. In this way, this approach constitutes a facilitating element for the inclusion of the activity into integrated management systems and local planning..

In any case, the mere fact of putting into place a group working jointly to produce principles, criteria and indicators and the accompanying learning process that it implies, helps to structure and institutionalise this system. This is an essential contribution to stronger governance and sustainable development.

Examples

Meetings and working groups organised by the EVAD project were, in some areas, seen as an opportunity to resume a constructive dialogue with the administration. The implementation of the EVAD project promoted awareness of the advantages of collective action and of a pro-active approach. The professionals understood that good long-term relations with their institutional environment and the key actors in their area were an essential condition for the survival of the industry, especially when the issue of access to sites is crucial. In most areas, implementation of the EVAD project has given rise to requests for its continuation and for the application of the produced indicators which means that a suitable system should be defined and institutionalised. This could, possibly with some reconfiguration, follow on from the collective groups created by the EVAD project. In several areas, collective meetings have strengthened the structure of trade associations, initiated new types of relationships with local authorities and in some cases identified the needs for structuring at other local or regional levels. The need to have interlocutors at each administrative and local level has become clear. Hence, when farms are geographically widespread, it is necessary to have representatives at local level or else a system which allows this function to be shared between producers according to the different authorities.

The project revealed a paradox: the professionals from large-sized companies, who are often better informed and connected to various information and action networks, have less time to devote to local actions and often automatically outsource some elements to communication agencies. On the other hand, those running smaller operations have more time and motivation to take part in collective actions, but they often lack legitimacy with the management authorities. The contrasting character of these situations strengthens the need for co-operation and professional structuring at the different levels.

EVAD

Chapter 2
Nesting of principles, criteria and indicators

2.1. Advantage of the nesting process

The approach is organised according to a hierarchical nesting process which makes it possible to link the indicators to the general principles of sustainable aquaculture. This type of nesting helps to put the definition process of the indicators into context, thus allowing it to be linked to local and/or sectoral issues.

This approach corresponds to the recent evolution of methods to implement sustainable development. In fact, the first phase in the development of sustainable development indicators relied on an inventory process organised according to the pillars or dimensions of sustainable development (environment, economic and social). This yielded detailed lists of indicators but little operational experience concerning their implementation. It is now accepted that a transversal conception of societal choices is to be preferred so that interactions between the social, economic and environmental dimensions can be included and the integrated nature of sustainable development brought to the fore. The second phase has tended to consist therefore of approaches by issue, by objective or by theme. This "principle guided" approach helps actors to adopt the general principles of sustainable development by setting them into context (Zaccaï, 2004; Droz and Lavigne, 2006). For example, the 45 French indicators of sustainable development correspond to 12 priority themes underpinning the national sustainable development strategy (Ayong le Kama et al., 2005). These approaches are better suited to the implementation of sustainable development but rely on the existence of a framework linking issues to indicators. Moreover, sustainable development studies increasingly stress the conditions and methods of implementation and thus refer to the issue of governance, in particular, with the strengthening of the objectives concerning actors' involvement, public-private partnerships and co-regulation promoted in Johannesburg in 2002. The implementation of sustainable development thus includes objectives relating to more broadly-based stakeholder involvement and greater transparency in the collective decision-making processes, in particular as regards the definition of sustainable development principles and issues. These elements imply some evolution in institutional systems, in the sense of the set of regulatory rules and institutions, and a strengthening of the actors' capacity to participate in these systems. This also refers to collective learning issues and to the issue of "empowerment" associated with governance. Hence, the suggested approach stresses not only the co-construction process but also identifies an institutional dimension to sustainable development in addition to the environmental, economic and social dimensions.

The approach suggested here is therefore structured according to a logical progression: "Principles, Criteria and Indicators" (PCI) make it possible to link the development of indicators to the issues, values, objectives and societal projects which constitute the background to sustainable development and which reflect these principles. This has been adapted from a similar initiative used to design a handbook of criteria and indicators for sustainable forestry management (Prabhu et al., 2000). Several other approaches are based on similar nesting concepts but use different terminology: they tend to provide a succession of ideas structured around the following terms: objectives, components, measures, indicators, indices, descriptors.

2.2. Introduction to the "Principles, Criteria and Indicators" (PCI) conceptual framework.

Using a cascading approach requires first the definition of the principles expressing the values and issues that underlie sustainability. These principles are then expressed through criteria corresponding to the variables that are appropriate to express these principles (monitoring of states) and to the "forcing" variables that determine the impacts on sustainability (monitoring of interactions). Finally, indicators are the methods used to measure these variables in the form of indices and threshold values which depend on available information and on the social acceptance of the standards they establish. This nesting chain allows for a "traceability" of indicators which then promotes their adoption. The following figures present this nesting and the types of analyses that were carried out to design the generic basis underlying the principles, criteria and indicators that are proposed in this guide.

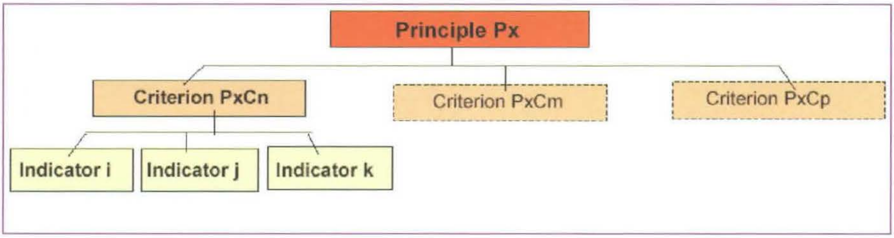


Figure 2. Simplified presentation of the nesting of principles, criteria and indicators

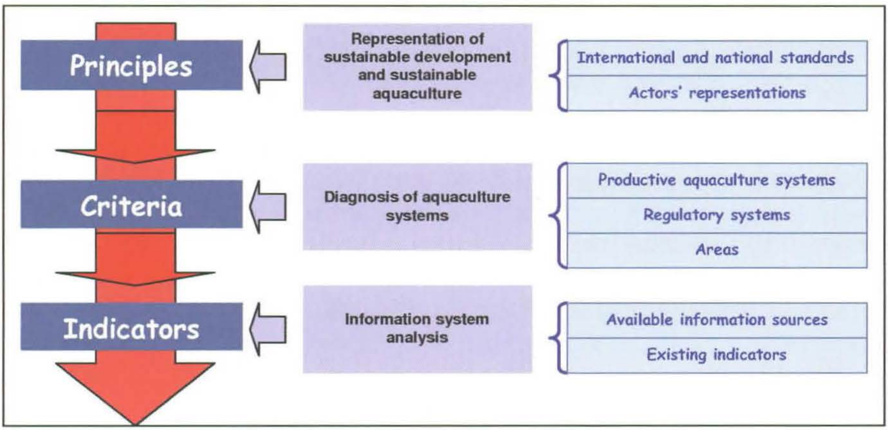


Figure 3. Linking the types of analysis contributing to the approach based on the nesting of principles, criteria and indicators

Once the hierarchy of the notions has been presented, the terminology must be specified in order to facilitate the application of the approach and the use of the generic foundation.

The notion of principle is understood as an action principle which occurs in the pre-implementation phase of a procedure. It derives from the latin "principium" which means: "what serves as a basis", so it has the property to be a founding element, the starting point from which a thought process or an action emerges. It corresponds to a postulate and may be considered to be a habit or a rule. In any case it covers a fundamental or general truth of sufficiently wide scope. Our approach consists of establishing sustainable aquaculture principles which correspond to the generally-accepted view, echoing the sustainable development principles established in Rio, setting out the guidance and the properties which condition the sustainable nature of aquaculture. So in this case, they do indeed correspond to action principles working towards sustainable aquaculture. The principles are short statements formulated with action verbs originating from management vocabulary such as for example "contribute", "ensure", "adapt", "strengthen", "improve", "implement" etc.

The notion of criterion is by nature quite close to the notion of principle because a criterion may be characterised as a second-order principle. This intermediate level expresses the fact that a principle has to be stated, specified, and qualified in order to be broken down into several homogeneous elements prefiguring the variables or the features which can be used for its evaluation. This breakdown makes the principles easier to understand and allows links to be established with the characteristics of the systems to which they relate. In mathematics, criteria correspond to the means used to establish a property. Here, they relate to the variables used to express a principle. Each principle is therefore defined by one or several criteria (between 4 and 10). The criteria are expressed using terms conveying the degree or the state of a variable: "Level of", "Significance of", "Existence of", "Access to", "Weight of", "Capacity to", "Nature of", "Control of".

The notion of indicator is a simple way to express the information related to a variable or a process. "*indicators are communication tools which serve to quantify and simplify information in order to make it comprehensible to a targeted audience. They are tools to assist monitoring, evaluation, forecasting and decision-making. They are defined with reference to previously-set objectives; comparing the value shown by an indicator with the corresponding objective helps to judge whether an action is effective*" (Madec, 2003). The introduction of the report on sustainable development in Europe (Eurostat, 2005) means that the indicator should be defined by its nature, rather than by its function. It stipulates that "*the indicators illustrate the variations observed according* *to the available data. Hence they clarify the nature of the issues described in the sustainable development strategy of the European Union according to priorities defined in Gothenburg and then in Barcelona. They are used to monitor the implementation of this strategy*". (Eurostat, 2005). Hence the indicator is only meaningful compared to the priorities which correspond here to the notion of principle.

The indicator fulfils the need to simplify and summarise the information as well as to standardise it. It has acquired a symbolic function which goes beyond the information provided by the value of the parameter (OECD, 1993). It has a qualitative or quantitative value which allows a state or an evolution to be expressed in a significant manner. It must be noted that some of the European sustainable development indicators have yet to be calculated due to the lack of available data (out of a total of 120 indicators, 11 have been replaced by substitute indicators and 34 have not yet been developed) (Eurostat, 2005). This kind of situation frequently arises with social and institutional indicators as shown by the governance indicators proposed by the UNDP (2002), half of which are evaluated by qualitative methods based on expert opinion. The evaluation is based on a "scaling" process (Schneider, 1998). This is a relative and ordinal indicator measurement which follows a hierarchical qualitative process based on classes representing scores related to situations (Moles, 1990). In this context, the notion of expert is not restricted to a particular status. On the contrary, any actor should be implicated, who, in a given place or at a given time, has relevant knowledge or information about a situation or a context related to the issue in question. An expert may therefore be a producer, a researcher, a social worker or a professional manager etc. They are qualified informants.

Indicators often lead to the development of indices and/or indicator systems (dashboards).

- An index consists of a set of parameters or indicators summarised or aggregated into a single value. An index may relate to the result of the relationship between two values (simple index) or several (composite indices). It is often with respect to indices that the most heated arguments develop as the choice of indicators and aggregation methods are highly subjective (Boulanger, 2006). The different weighting of fundamental indicators depends on the relative significance given to the components, thereby showing the political role of indicators, as is illustrated by the controversy surrounding the measurement of economic well-being (Gadrey and Jany-Catrice, 2005). It should be stressed that no weighting is in fact a weighting system where the same weight is given to each element.

- A system of indicators is developed when several indicators are co-coordinated systematically. This constitutes dashboards which are at the heart of observation systems and observatories.

Indicators and indices refer to simple or composite data which allow measurement of the state or the evolution of the variables with respect to the criteria. The choice of these data must meet a number of conditions, such as the accuracy of the indicator measurement from the point of view of its relationship with and relevance to the criterion, the reliability with respect to data quality and the precision of the measurement, temporal consistency, and the availability and access cost as these condition whether monitoring can be operational and feasible. Numerous other conditions are mentioned in the literature concerning indicators and information systems such as, for example, the consensual and comprehensible nature of the indicator, its proximity to decision-making systems, its stability through time, its verifiability, its capacity to meet needs, its adaptability to various scales, its robustness and its institutional legitimacy. According to experts from the Global Reporting Initiative (2000), the essential qualities that an indicator must display are relevance, reliability, clarity, comparability, appropriateness and verifiability. The perfect indicator is something of a myth; compromises have to be made between these features depending on the context, the indicator category and the types of use. Depending on the target functions, different indicator qualities will be highlighted. The normative and social nature of any indicator (postulate 1) should be recalled. An indicator "*is not merely the measurement of a parameter but the response to a social issue related to an identified present or future issue. Intended for a large number of actors who are likely to have different opinions, its interpretation requires a consensus*" (Turpin, 1993). Hence, the aim might be to indicate the sustainability of a system or to compare several systems, it might be to provide an information or communication tool, or it might be to strengthen the implementation and evaluation of management policies by linking objectives and management measures and by allowing the impacts of interventions and the achievements to be measured.

Given the operational requirements of the approach, the guide sets out the following specifications:

- The principle corresponds to a postulate or a priority which determines the development of actions promoting sustainable aquaculture (general objective).
- The criterion breaks down the global principle into themes or homogeneous characteristics and makes the link with the relevant variables (specific objectives).
- The indicator allows the criteria to be measured. It can be quantitative or qualitative. It becomes an index when it aggregates several sets of data. It must be accompanied by a descriptive sheet which characterises and specifies the way it was constructed and is calculated.

2.3. Introduction to the thirteen principles for sustainable aquaculture

The principles outlined in the guide derive from the identification of the major challenges faced by aquaculture. This identification was based on two complementary and interactive approaches:

- taking into account the representations of producers and stakeholders in aquaculture systems concerning both aquaculture and the possible and desirable ways to develop towards sustainable aquaculture. The farming systems which have been the object of the EVAD project experiments were chosen to represent a variety of species, of production systems, of technical itineraries, and of geographical and institutional contexts (box 3). Hence, the representations collected in each survey cover a broad range of opinions which, in such a subjective area, may be considered to be adequate.
- analysing international and national standards represented by existing sustainable aquaculture reference frameworks, and by the recommendations for the implementation of sustainable aquaculture formulated by international organisations, research institutes, professional organisations or NGOs related to the sector or to aquatic ecosystems (Mathé et al., 2006).

Textual analysis of the actors' opinions taken together with the reference frameworks highlighted a few key themes, from which thirteen principles for sustainable aquaculture were identified. The box below illustrates how, beginning from the information collected through the surveys, the principles were formalised in such a way as to be generic. It should be noted that issues raised by actors, even though formulated differently because of the context or the culture, proved quite easy to reconcile and collate.

> The principle "To contribute to meet nutritional needs" was stated by actors through some of the following suggestions, which are given as examples and do not represent all the statements made. "Replace a natural system which is deteriorating with a man-made system and produce fish"; "a role in providing fish resources"; "provide fish at a reasonable price"; "provide omega 3 and nutraceuticals"; "provide a healthy product at a reasonable price"; "produce good quality food"; "provide animal proteins".

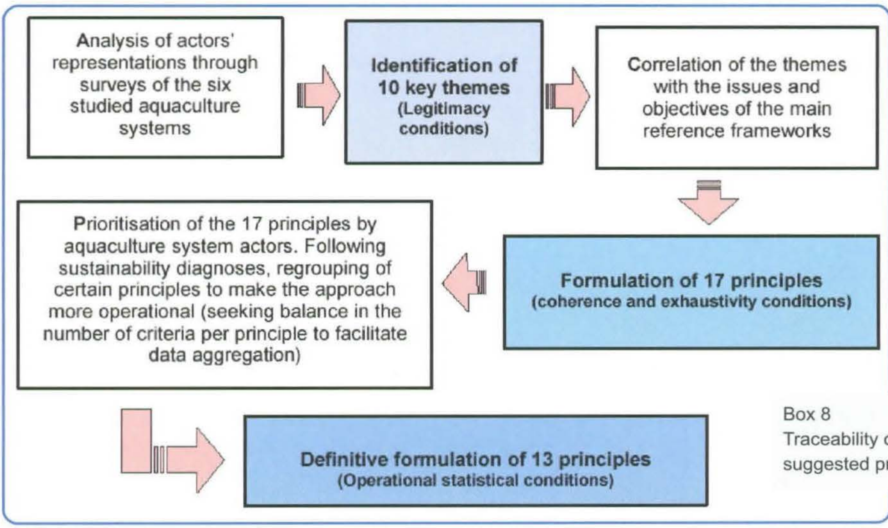
Box 7
Example of correspondence between the principl[e] and issues raised by actors

Classifying the principles a posteriori by dimension provides a means to check the relative significance of the four dimensions of sustainable development (table 3).

Table 3. Grouping aquaculture sustainability principles and aquaculture zones according to the dimension of sustainable development where they prevail

Technico-economic dimension	P6- Increase the capacity to cope with uncertainties and crises
	P7- Strengthen the long term future of exploitations
	P2- Develop approaches which promote quality
Environmental dimension	P3- Ensure that natural resources and the environmental carrying capacity are respected
	P4- Improve the ecological yield of the activity
	P5- Protect biodiversity and respect animal well-being
Social dimension	P1- Contribute to meet nutritional needs
	P8- Strengthen sectoral organisation and identity
	P9- Strengthen companies' social investment
Institutional dimension	P10- Strengthen the role of aquaculture in local development
	P11- Promote participation and governance
	P12- Strengthen research and sector-related information
	P13- Strengthen the role of the State and of public actors in putting sustainable development into place

The iterations leading to the formulation of these principles may be summarised (box 8). As they derive from surveys carried out in very diverse aquaculture systems and from the reasoned contributions of researchers taking into account the main reference frameworks and the constraints of statistical processing, these principles have a generic scope. The detail at each stage shows that they were built whilst respecting the multiple conditions in terms of legitimacy, coherence, exhaustivity and operationality. Likewise, the formulations were progressively revised taking into account the comprehension difficulties observed when experimenting the approach in the six study areas. Finally, it should be noted that the numbering of the principles derives from the original classification of the ten themes identified from the actors' representations. These were originally organised as a function of the decreasing importance of the statements. Later classifications attempted to combine and group closely-related principles whilst avoiding merging the four dimensions of sustainability. It is very important that the order in which the principles are presented does not guide the choice of the actors when they prioritise these principles.



Box 8
Traceability of the 13 suggested principles

The experiments that were undertaken using the guide show the diversity of priorities according to the context, as allowed by the adaptive nature of the suggested process. It must be borne in mind that this is a reference framework intended to guide the approach whilst favouring local specificities. This leads to various routes and results depending on the contexts in keeping with the process of sustainable development.

Hence, the prioritisation of the 13 suggested principles by area highlights differences but also identifies "common" principles which were selected from the first six main principles selected by several areas, including whether they relate to aquaculture in developed countries or in developing countries. Table 4 below shows the first six principles selected by each area and across the whole set of areas. Three categories of principle can be identified according to selection rates:

- Principle P1 was selected across all the areas, usually in first place with a much higher score for the number of times selected than the other principles.
- Principles P3, P5, P7 and P10 were selected by several areas achieving variable scores but can be considered as common principles.
- Principles P2, P4, P8 and P12 were considered to be priorities in only one or two of the sites and are therefore more context-dependent.

Finally, it should be noted that only P6 and P9 relating respectively to the capacity to cope with uncertainty and to social factors were not selected as a priority in any of the sites.

Table 4. Classification of principles according to the number of times they were selected by the actors across all the areas

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Brittany	5		2	2			1				4		
Méditerranean	4	1	2				3	5					
Philippines	1		2	5	3					4			
Cirata (Indonesia)	1		2		5			5		4		3	
Tankit (Indonesia)	1	4			3		5			2			
Cameroon	3						5			1		2	3

The diversity of the results can also be expressed by comparing the results of the selections to the issues and factors which were revealed to be significant in the study of actors' representations (Table 5). This analysis shows the positive role of the discussions which put some elements into perspective whilst including others that had not been spontaneously identified originally. In particular, aquaculture professionals whose representations used to relate mainly to the long term future of the exploitation (P7) at the micro-economic level of the exploitations have become aware of the larger picture and of the need to adopt a pluralist approach to sustainable aquaculture. Such different results between initial representations and final selections should not be interpreted as a weakness but, on the contrary, as the result of the learning process generated by the co-construction approach which promotes discussion. The fact that nearly half of the selected principles correspond to priorities expressed by the actors must be acknowledged.

Table 5. Comparison of selection results with priorities expressed by actors during fields surveys of their representations

	Selected principles		Unselected principles	
	corresponding to priorities expressed by actors	not corresponding to priorities expressed by actors	corresponding to priorities expressed by actors	not corresponding to priorities expressed by actors
Economics	P7		P6 and P2	P5
Environment	P3	P4		
Social	P1		P8	P9
Governance	P10 P11 and P12	P13		
TOTAL	6 principles	2 principles	3 principles	2 principles

Chapter 3
Linking phases and implementation stages

The joint approach to building indicators for sustainable aquaculture suggested here is a support tool providing reference points for the development of a system of sustainability indicators without the imposition of a rigid framework. Lessons can also be drawn from the experiments carried out in diverse contexts and aquaculture systems.

It is a tool designed to support actions, the design and the choice of indicators and the development of an observatory which is able both to:

- develop a system of sustainable development indicators for aquaculture, defined as a subset of the generic foundation, adapted to a given aquaculture system;
- initiate a participatory approach and a collective learning process facilitating the ownership of sustainable development and the institutionalisation of monitoring and of the implementation of the system of indicators that has been developed.

The use of the generic foundation provided in the guide is based on three phases and ten chronological stages which, depending on the case, follow from specific work by the pioneering group or from participatory work by the stakeholders. The pioneering group refers to the team (often small in size, sometimes a single person) in charge of facilitating and co-ordinating the development of indicators, either as the initiator of the approach or because they have been given the task. As specified previously, the co-construction approach suggested here is based on a mode of interaction between the members of the pioneering group and the stakeholders involved, which is deliberately flexible and light.

It is possible to imagine closer action-research partnerships in the future. The loop suggested here can then be extended becoming the first loop of a spiral where several loops follow one another. This image of a spiral is often used to illustrate a procedural and interactive process, particularly when the learning function is determinant.

Figure 4 shows the links between phases and stages. Three phases set the pace for the implementation of the suggested approach. They represent the traditional progression of any project implementation: preparation, implementation and evaluation. Therefore we have:

- a preparatory phase (four stages) which tends to be cognitive and comprehensive
- a principle and criterion selection phase, which is at the heart of the approach (three stages) and tends to be comprehensive and participatory
- a validation phase (three stages) which may be described as participatory, reflexive and cognitive.

This implementation process represents an indicative route map which can be amended depending on requirements. The relative weight of the three major phases (as well as the stages within each phase) may differ according to the context and the area. In particular, they may be undertaken in more or less depth, depending on:

- the level of prior knowledge that the pioneering group has of the aquaculture systems for which sustainable development indicators are being designed (variation depending on the information factor);
- the level and the types of institutional structure and organisation of the aquaculture sector and of their relationship with the exploited areas (variation depending on the governance context).

These two aspects may suggest different variations in the application of the suggested approach (see part 6). In fact, the information factor will determine the importance of preliminary surveys and the need to strengthen the preparation phase, whilst the governance factor will determine how to organise actors' involvement in the process and will principally affect the selection and validation phases.

Changes might also be contemplated according to distance and the geographical dispersion of the actors. If the actors are too widespread, it

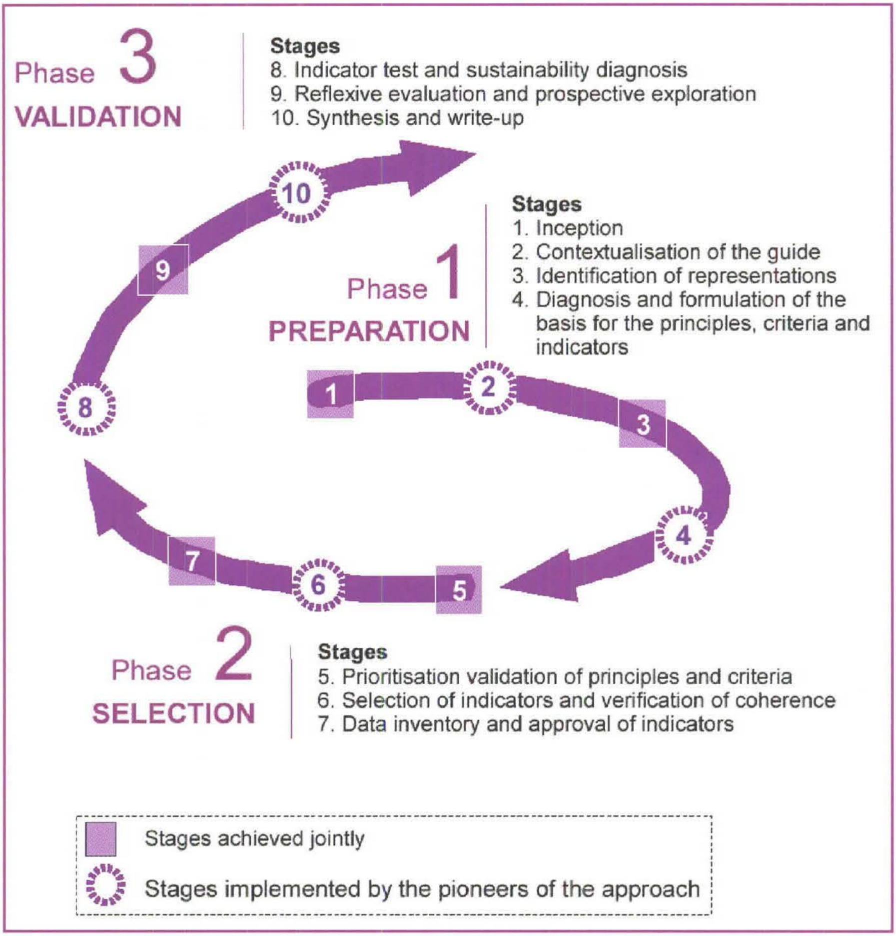


Figure 4. Implementation process for the co-construction approach

may be necessary to reduce or cancel collective meetings and replace them with bilateral discussions. Such a situation would necessarily require strengthening the involvement of the pioneering group, which would play an increased role in facilitation and in transmitting information and opinions that are put forward.

Finally, it must be stressed that the phases and stages are presented in a linear fashion so as to show the linkages between the stages and to facilitate the comprehension of the approach from an educational point of view. However, the stages are interactive in the sense that retroactive loops can occur with some of the elements which have already been defined in previous stages having to be re-assessed depending on the results achieved at a given time. The process is not set in stone and can develop along the way both in its implementation methods and its objectives. In particular, when the co-construction process is successful, it is quite common for the pioneering group to continue and seek to achieve more demanding objectives than was originally the case.

EVAD

Chapter 4
Detailed stages for each phase

This part specifies the working stages within each phase and presents some useful points for the users of this guide.

- What actions should be planned?
- In what order should they be implemented?
- Who is involved? In which action?
- How to chose the actors who are going to be involved?
- How to mobilise the actors and how to organise their involvement?
- How to distribute the various roles?
- What methodological tools can be used to support the planned actions: surveys, facilitation of participation, software?
- How long should each stage take?

Before looking at the stages in detail, one of the distinctive original features of this guide, which affects its implementation, must be highlighted. The suggested approach is based on a territorial approach to sustainable development. This territorial dimension is fundamental to the appropriation and the institutionalisation of sustainable development. Hence, the issue of aquaculture sustainability is deliberately addressed from two different, complementary and interactive points of view: the sustainability factors for aquaculture farms themselves and the contribution that aquaculture systems make to the sustainability of the territories or areas where they are implanted. Therefore, some principles may lean more strongly towards one or the other of these aspects and the set of criteria and indicators suggested by the generic foundation are organised into two broad classes which correspond to these two options. This distinction aims to facilitate a modular application of the approach according to contexts and needs.

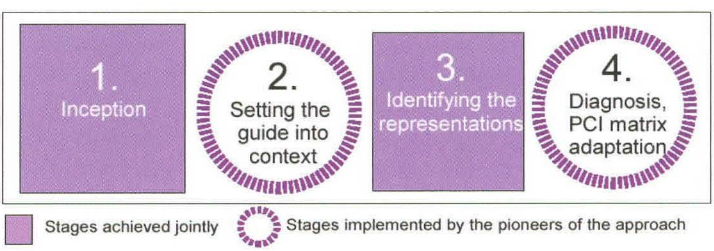
The introduction to this guide highlighted the fact that potential users could be producers seeking, for example, to implement a certification scheme or an ecolabel for their activity or institutional actors from sectoral or regional organisations. However, regardless of the kind of actor launching the initiative, it is important to avoid a too rapid association of the categories of actors and the sectoral or regional approaches to sustainability. Such simplification could lead to approaches initiated by producers (or strictly sectoral bodies) being focused on the monitoring of farm sustainability. Trials of the approach have shown that the distribution of the types of principles and criteria selected as priorities by the actors indicated a specialisation: producers are usually more sensitive to economic dimensions and to the sustainability of aquaculture enterprises whereas institutional actors take a more balanced view of the complete set of sustainable development dimensions. The interest of the joint approach is precisely to avoid these divisions.

An overly restricted vision of sustainability could lead to stalemate in the medium term and miss positive opportunities to redefine the standards or to improve the image of the activity which are usually expected to arise from co-production. As stressed in the introductory postulates, it is important to avoid restricting the approach and the range of actors involved.

Phase 1. Preparation phase

The preparation phase is important as it affects the ease of implementation because it will be determinant for the adaptation of the generic foundation and the suggested procedure to local specificities and needs. It can be divided into four successive stages.

The four stages of the first phase



Stage 1. Inception

This is a strategic stage for the joint process since it defines, as early as possible, the pioneering group which is to be included in the joint approach to building the indicators. The figure below shows an example of a structural typology of the types of actors who may be involved. In this case, apart from consumers and citizens, it concerns the actors who were included in the survey of representations within the framework of the EVAD research project.

Starting from the example of this general typology and depending on the context and the scale of implementation of the approach, an inventory of the types of actor who could be involved, in a broad sense, must be carried out in order to identify the composition of the pioneering group and to select the stakeholders who will be included in the approach, as well as the types of actor to be surveyed. As mentioned in the introduction to the postulates underlying the approach, the pioneering group must ideally comprise at least two types of actor among the most significant for the structure of the process, which are the operational groups within the whole chain, i.e. the productive sphere (including downstream), the institutional sphere (administration, associations, NGOs) and the cognitive sphere (research and training). The actors' legitimacy within these different spheres is based on different factors:

- fish-farmers or their professional representatives are legitimate as they are the first to be concerned by the approach.
- research or training institutions may be a legitimate partner as they have information at their disposal and the technical skills required to develop and calculate indicators. Researchers in both natural and human sciences should be involved in order to respect the balance between the dimensions of sustainable development.
- institutional actors have the political legitimacy to take part in the approach and their inclusion may guarantee a degree of institutionalisation of the indicator system that is established. When institutional actors produce administrative standards for the sector or the region, their inclusion can "slow down" the process as it becomes necessary to clarify conflicts and power relations. But once these constraints have been overcome and subject to genuine openness in discussions, their integration becomes an opportunity to revise the standards' system through

the definition of new compromises and to allow more retiring actors to express their opinions.

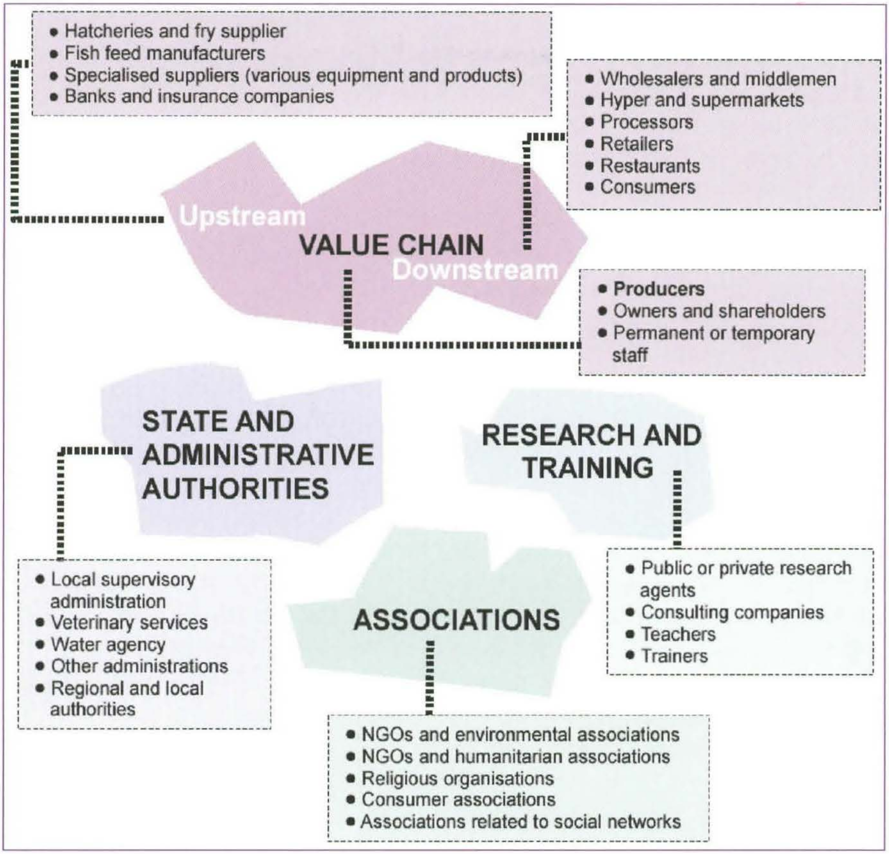


Figure 5. Presentation of the types of stakeholding actors in aquaculture systems

The term "stakeholder" encompasses actors who might be described in a variety of ways; such as concerned actors, involved actors, or actors representing particular issues.

The most frequently quoted definition of the notion of stakeholders is from Freeman's seminal 1984 book, i.e. "any group or individual who can affect or is affected by the achievement of a firm's objectives or by public policy". If the group is not delimited, defining boundaries becomes an issue and many typologies become possible. Among these, criteria concerning the distance to the strategic centre and the extent to which relationships are voluntary are the most frequently used. This gives the classic distinction (Caroll 1989 cited by Pesqueux, 2006) between (i) the primary or contractual stakeholders comprising actors who are in a direct contractually-defined relationship based on an explicit notion of partnership and (ii) secondary stakeholders comprising all the actors who constitute the environment, broadly speaking, according to a "societal" conception of the relationships between the organisation and its "environment" (Pesqueux, 2006). This issue includes the sharing of representations and information as widening the stakeholder circle leads to the multiplication of values and representations.

Box 9
Detail on the notion of "stakeholders"

It should be stressed that the perspective of the sustainability approach that is selected also affects the composition of the pioneering group and the choice of stakeholders, regardless of whether the sustainability factors relate to aquaculture farms or to the contribution of aquaculture systems to territorial sustainability.

Once the pioneering group has been defined and the future stakeholders identified, this stage should end with a first collective workshop bringing together the main partners and the stakeholders in order to introduce the approach and collectively validate its objectives. A workplan can be established at the end of the collective discussions.

The outcome of this first stage is:
(i) a structural matrix of the types of actor
(ii) the creation of a pioneering group
iii) the identification of the participating actors and those to be surveyed
iv) a first collective working group

Stage 2. Setting the guide into context

The guide must be set into the context according to the objectives and the characteristics of the region. The pioneering group must adopt the procedure, specifying the implementation methods designed as variations of the reference model (figure 4). This is a "cognitive" phase when the members of the pioneering group define the work programme, clarifying the ways in which the approach can be applied so that it is adapted to the region. It is necessary at this stage to investigate the methods to mobilise the stakeholders in the approach: Should it be through surveys and, if so, using what type of questionnaire or interview guide ? Should collective workgroup meetings be organised ? How can discussions be facilitated within collective groups ? The answers to these questions will depend on the skills and enthusiasm of the pioneering group and on the characteristics of the aquaculture systems in terms of:

- geographical distribution,
- strategic importance of the sector,
- maturity and potential interest in the approach,
- the degree of professional structuring,
- whether other approaches to sustainable development exist in the region,
- whether there is prior knowledge of the issues and consequences of the sector's evolution towards sustainable aquaculture.

The issues of financial resources available to the pioneering group and of the timescale involved in implementing the approach are, of course, criteria which affect the possible options and may justify some reorganisation. It must also be noted that, as for the composition of the pioneering group, the perspective of the selected sustainability approach (sustainability of aquaculture systems and contribution to regional sustainability) determines the methods used to put the guide into context and these often combine these two complementary features.

The approach being procedural and adaptive, the objective of this stage is not to produce an implementation plan that is set in stone. On the contrary, this plan must include the capacity to adapt during the different stages, particularly to integrate collective learning. It must be revised periodically so that stakeholders who are involved will be more or less supportive of the approach and eventually become pro-active.

The outcome of this second stage is:
(i) adaptation of the implementation loop of the approach to the context (validation and prefiguration of each stage)
(ii) preparing survey questionnaires or interview guides
(iii) inventory of existing initiatives and reference frameworks for sustainable development

Stage 3. Identifying the representations

Analysing representations is a key moment in the approach and must lead to the identification of the major sustainable development issues for the relevant aquaculture system(s). Any change or innovation must be thought through and implemented taking account of the actors' attachment to existing systems and values. The analysis of representations aims to identify the values held by the actors. This means that in order to facilitate any evolution, there must be no sudden break between the existing value system and the new reference framework relating to sustainable development, as it is understood by the actors.

Representations may be defined as "types of knowledge that are socially developed and shared, and which contribute to the construction of a common reality for a social group" (Jodelet 1989). They are diverse, they depend on contexts and regions, actors and information systems, and determine the factors affecting actors' actions. A social representation is the interpretation that people have of their reality. It depends on the available information that they have together with their activity and experience, their status as a social actor and their interests. Representations provide a point of view on reality and if conveyed by a dominant actor who is able to impose it on others, they become a common reality shared by the whole of society (Gendron 2007). They are constructed within the framework of daily practices and shared by a whole social group, over and above individual characteristics. They comprise ideas, beliefs, judgments, world visions, opinions or attitudes. They frame and guide individual actions particularly by establishing "limits" to what is suitable and play a significant structuring role in professional reference frameworks.

Box 10
Detail on the notion of representation

This stage implies qualitative surveys of a wide variety of actors (identified within the matrix established above), in order to obtain their points of view on aquaculture activity, on sustainable development and on the consequences and the means of applying policies favourable to sustainable aquaculture to the relevant aquaculture system(s). Surveys can be undertaken (cf. appendix 2 on interview guide) through bilateral discussions or focus groups which can comprise actors of different or similar types.

However, it should be stressed that facilitating collective discussions requires specific skills relating to group management. In particular, all participants must be given a fair chance to express themselves. The aim of collective discussions is to provide a feedback on individual points of view so that actors are aware of the diversity of issues and expectations. This is part of the collective learning process. The risk is that retiring individuals do not express themselves or that minority views are not aired. Care must be taken to avoid this, both by anticipating the risks in the composition of the group and if necessary by constituting sub-groups and collecting in writing all the stakeholders' individual opinions at the beginning of the meeting so that they cannot be influenced by opinions aired as the discussion progresses. Finally, it should be borne in mind that too large a group (over twenty people) does not offer favourable conditions to hear everybody.

Analysing stakeholder representations consists of studying, through the replies and the terms used by the stakeholders, the factors and the values that are important to them. This consists of a discourse analysis in the sociological sense. Comparing results concerning the major representations and issues identified using the reference principles suggested by the guide can help the pioneering group to select, complete and eventually reformulate these principles in order to establish reference principles for the relevant aquaculture system(s). The aim is to include all the representations from a deliberately diverse set of stakeholders so that all the dimensions of sustainable development can be addressed. In this spirit, a set of ten principles seems to be the minimum that is desirable, taking care however that the four dimensions of sustainable development are represented, and equally insofar as possible.

Box 11
Some recommendations concerning surveys *1/2*

The aim is to review a few fundamental elements concerning the particular nature of interviews which aim to uncover individuals' representations. Some examples of questionnaires and interview guides are proposed as complementary material in the appendix 2.

Recommendation no. 1. Actors have little time to devote to interviewers, so the survey must be precise and the interview should not exceed a certain time. This can vary depending on the work of the people being surveyed and the time when the survey is carried out. But it should never exceed two hours.

Recommendation no. 2. The interview is framed by a questionnaire or interview guide which may combine open questions (free response) or closed questions (selection or prioritisation of pre-established responses). For the most qualitative surveys carried out on the basis of open questions, an interview guide should be used which lists the issues to be addressed. The development of the questionnaire or the interview guide usually requires field visits or informal interviews with key actors who have a broad view of the sector and/or region. It is the "interviewer" who manages the interview according to his/her interlocutor, i.e. he or she can change the order of the questions depending on the course of the interview, provided all the points are covered by the end.

Recommendation no. 3. The interview follows three axes: structural elements, discourse (which reflects representations) and free expression.

Structural elements concern the characteristics of the surveyed individual and of his/her enterprise or institution. These include factors such as age, social status, years in the métier or the institution, origin, level of training etc. as well as data concerning the size of the enterprise, the nature of the means of production, the types of product ... or the functions of the institution if the interviewee is not a producer. These structural variables can be used to establish typologies.

The discourse concerns the meaning of the terms used by surveyed individuals when expressing their opinions. This is an essential element when studying which value system individuals refer to and what their representations are. This highly qualitative aspect means that words and sentences used have to be retranscribed exactly, together with the moment when they were used. When the survey is predominantly qualitative, the interview should be recorded and then retranscribed in part or in full so that a textual analysis can be carried out. It is through this discourse analysis that the interviewee's representation of sustainable development, his/her metier and development possibilities etc. can be understood. It is essential not to limit oneself to direct questions asking how the individual represents sustainable development or aquaculture. It is important to ask indirect questions to make him/her talk around these notions. It is important to gain the interlocutor's trust asking for example: "Present your farm, your family, your metier", "How do you perceive such an action?", "How does or will different actions affect your farm, your métier, the value chain, the region?".

Box 11
Some recommendations concerning surveys
2/2

Comparing direct and indirect responses makes it possible to evaluate the level of awareness and knowledge of the individual concerning the ideas discussed. This work on discourse analysis enables an understanding of how the person represents these notions and why he/she has this representation.
Free expression makes it possible at any time, or at the end of the interview through a specific section, for the interlocutor to mention any other aspect of importance to him/her. This is also an opportunity for him/her to ask the interviewer questions.
Recommendation no. 4. Closed and open questions should alternate and a balance must be found. Depending on the case, there might be variations with specific questions according to the types of people interviewed.
Recommendation no. 5. The questionnaire or the guide should be tested on a few people in order to be improved or completed.
Recommendation no. 6. The number and the type of people to be surveyed depend on the objectives of the survey.
Recommendation no. 7. In order to avoid misunderstanding, meetings should be organised by post, telephone or by the presentation of an official letter of introduction at the beginning of the interview. When possible, it is preferable to make an appointment explaining clearly the purpose of the survey. In some countries, the local or traditional authorities must be contacted first in order to clarify survey issues. Finally, when the interviewer arrives, if the actor to be interviewed is working, it is important to suggest waiting or even, depending on the case, to offer to help for a while. At the beginning of the interview, the survey's objectives and the guarantees of confidentiality must always be reiterated.
Recommendation no. 8. Once the interview is over and while "still fresh" a preliminary summary of how the interview went should quickly be written up (degree of reliability of responses, whether the person interviewed is keen to be involved in further surveys) and to summarise the most significant points and those that must be checked.
Recommendation no. 9. The replies must then be analysed systematically by issue and by broad theme. Surveys must be complemented by field observations and informal discussions with key-actors.
Recommendation no. 10. It is highly recommended to report the results of the survey at a collective meeting (where it is then very important to note the reactions and further informations) or by sending a summary of the main results.

These recommendations concern "face to face" interviews when the interviewer meets the interviewees individually. In some cases, the surveys can be carried out collectively (focus groups). In this case, it is important to be aware that replies are affected by what other people think and by previous replies. And also that the status and the personalities influence speaking time. Discussions should be recorded or several people should take notes.

The notion of survey representativeness can be addressed in two ways: statistical and comprehensive. In the first case, it is addressed through the capacity of the surveyed sample to represent the characteristics of the population from which it is drawn. This property depends in particular on the size of the sample which can be calculated using sampling theory so as to minimise statistical errors. Representativeness also depends on the variability of the initial population which may, when the factors affecting this variability are known, allow the use of stratified or cluster sampling (Desabie, 1977). Hence, the survey strategy depends on the population characteristics and the prior knowledge of the population. It also depends significantly on the survey's objectives and its resources in terms of available time and manpower. In the case of a frame survey, when results must be extrapolated to the whole population, the strategy depends primarily on the objective of minimising survey error, often leading to a high sampling rate. This type of approach and sampling is usually used in the case of simple causality.

In the case of the comprehensive approach which relates to surveys of a more qualitative nature and which aims to explore and identify multiple and diverse causal associations, the sample is constructed deliberately and the sampling rate issue becomes secondary. By their very nature, representations are subjective and personal. The objective cannot be exhaustivity or representativeness but rather the degree of diversity. The size of the sample matters much less than its ability to explain and illustrate variability. Generally in this case, the first stage consists of defining a typology from the factors influencing representations. The number to be surveyed then depends on the typology. Hence, a higher sampling rate is required when the small number of farms leads to significant singularities. For this type of approach, it is not the number of actors surveyed which matters. The quality of the survey stems from two conditions. First, it is important that all the major actors determining the dynamics of the sector and/or region can be encountered and this implies effective integration within the social and professional networks in order to obtain these appointments. Second, the widest possible range of type of actors should be seen (figure 5).

The outcome of this third stage is:
(i) the identification of the issues and the representations of the actors in relation to aquaculture and sustainable aquaculture
(ii) the selection and the formulation of principles adapted to the context

Stage 4. Diagnosis and formulation of the PCI foundation (Principles, Criteria and Indicators)

This final stage of the preparation phase aims to provide a diagnosis of the sector's situation. What are the issues ? How many fish-farms are there ? What are the types of enterprise ? What are the constraints and the strengths ? How is the sector regulated ? Aquaculture systems must be characterised, particularly through a structural and functional typology of the farms, i.e. by using defining variables such as the size, the kind of property rights for factors of production and access to land, the species or the farming techniques, marketing methods, professional organisation structure and the regulatory systems, etc. This typology should allow an accurate sustainability diagnosis by showing sustainability degrees or differentials according to the type of exploitation and allow the identification of the types of farming system that should be encouraged from a sustainable development viewpoint.

Depending on prior knowledge of the relevant aquaculture system(s), this diagnosis can be undertaken using different methods:

- expert opinion
- through the synthesis of available information
- carrying out one or more specific frame surveys (cf. appendix 2 on questionnaires and list of decisive features of regulatory systems).

Using this diagnosis, any element which is not adapted to the context or to the region must be removed from, and any missing elements added to, the generic list of principles, criteria and indicators. It may also be useful to reformulate some of the headings to improve local actors' understanding. The result is then a context-based list of principles, criteria and indicators which can be used for the selection phase.

Once more it should be borne in mind that even if priority is given to one or other of the aquaculture sustainability approaches (aquaculture farm sustainability or contribution to regional sustainability), both categories of criteria and indicators should be retained and the composition of working groups should be widened to avoid restricting the scope of the approach.

The outcome of this fourth stage is:
(i) a diagnosis of the relevant aquaculture system(s) establishing in particular a typology of the aquaculture systems
(ii) the production of a foundation of principles, criteria and indicators in the form of a reference list for the relevant aquaculture system(s)

Phase 2. Selection phase

The selection phase represents a strategic opportunity for partner actors to select the principles and criteria they consider the most appropriate for the implementation and monitoring of aquaculture systems. This phase comprises three stages and it is essential that it should involve a broad range of actors.

The three stages of the second phase

Stage 5. Prioritisation validation of principles and criteria

As for the analysis of representations above, this stage can be based on bilateral discussions (even postal-based) or on collective discussions as long as a principles and criteria selection form is distributed to, and completed individually by, the participating actors. Depending on the context (geographical dispersion of actors, timescale…) and as shown in figure 6, many methods or itineraries may be used to undertake this stage. However, a collective workshop has the advantage of being a symbolic moment, as was the inception phase for the pioneering group, in that it launches the joint building process with the relevant participating stakeholders.

Diagnosis report. Reporting the diagnosis is an way to introduce this principles and criteria selection phase. It is indeed important to present the results of the preparation phase (diagnosis) and to reiterate or present the overall approach and more precisely the practical selection methods that actors will be required to use. If all the stakeholders did not take part in the first workshop during the inception phase of the approach (table 1) as it was considered to be too early, it is now necessary to establish a consultation and discussion mechanism with a wide range of the actors involved in aquaculture.

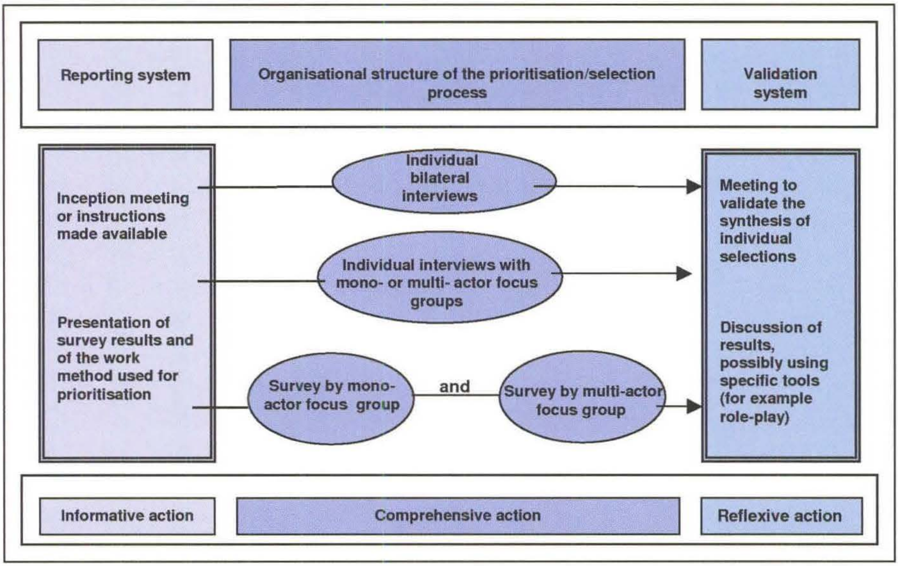


Figure 6. Illustration of some possible itineraries for the selection stage of principles and criteria for aquaculture sustainable development

Principle prioritisation means that each participating stakeholder lists in decreasing order of importance the 10 principles they consider to be the most important in the reference list produced during phase 1 (a context-based sub-set of the foundations suggested in the guide). The most important principle scores 10 whilst the last one to be selected scores 1. The remaining principles score 0. Using these individual scores, the pioneering group works out the average per principle distinguishing results by categories of actors: by zone, by type of aquaculture system, by type of actor.

Then, for each of the ten selected principles, the participating stakeholders evaluate the criteria of the 10 principles which were previously selected as "a priority", "important", "to be integrated later on", "secondary" or "don't know". This classification is then analysed by the pioneering group which gives each category a weighting coefficient (for example 8 for "a priority", 4 for "important", 2 for "to be integrated later on", 1 for "secondary") in order to obtain global estimates of average scores by criterion and for the previously-distinguished categories (by zone, by type of aquaculture system, by type of actor etc.). It should be noted that at this stage, the actors are not asked to give their opinion on the indicators. For educational reasons, it is however necessary to combine the criteria with some examples of indicators in order to give the actors a more operational feel for the criteria.

The differences in results by actor category enables a characterisation of the relative importance of issues according to the actors and are therefore an important feature of the learning process. Following individual selections and their summary statistical processing, the results are discussed at a collective workshop. This is a collective and reflexive action on the issues and methods of sustainable aquaculture. It enables clarification of the principles and criteria which make the most "sense" to the actors and of the reasons for rejecting the principles and criteria that were not selected. This procedure contributes to a negotiated vision of what actors consider to be sustainable development, the way in which everyone can and must contribute and the rules used to “judge”. Selected principles and criteria must be sufficiently clear to be understood by all and to be the subject of a convergent interpretation. On this account, they can be reformulated following the collective discussion. These principles and criteria must, as far as possible, be common to the different types of actor involved. The presentation of the results according to the types of actor can promote awareness of the reasons behind any differences. It can also help with convergence towards a set of selections in a common list of principles and criteria.

This is therefore an essential stage for collective learning and the building of a common language and project for aquaculture sustainable development.

The outcome of this fifth stage is:
establishing a reduced list of principles and criteria for sustainable development which is relevant to the context and the region
and shared by the largest number of types of actor

Stage 6. Indicator selection and verification of the coherence of the whole

The pioneering group may possibly propose, following the workshop discussing the results of the selection by the actors, to reintroduce some principles or criteria which are thought to be essential but have not been selected. This action should allow for external factors to be taken into account, in particular forecasts which could help anticipate a minima the future dynamics of the aquaculture system(s), as well as the necessity, in order to follow a sustainable development process, to maintain balance in the treatment of the four dimensions of sustainable development (environment, economics, social and governance).

Starting from the list (added to, if necessary) of selected principles and criteria, the pioneering group must then identify and select the appropriate indicators to reflect the variables which characterise each of the criteria. This stage requires special skill and knowledge. It is particularly crucial to study existing information systems in order to develop the new sustainable development monitoring system so that it interacts with these existing systems. This condition reduces the cost of collecting information but also facilitates understanding and use of the information system, a part of which comprises indicators which are already familiar to actors. Adopting the indicators suggested by the guide, on account of the links that have been established with several international initiatives, helps to compare results at different scales.

It is important to stress that indicator selection must not be determined solely by the availability of information and data. Many information systems, particularly those relating to sustainable development and especially when they concern its social and institutional dimensions, rely on qualitative indicators evaluated by expert opinion.

Finally, in this last stage, the pioneering group must suggest ways to implement operational monitoring of aquaculture sustainability.

These suggestions must focus on:

- the methods used to report results depending on the target audience (observation systems often distinguish between a panel of indicators intended for the general public or the decision-makers and a more detailed panel of indicators intended to guide interventions);
- the institutional mechanism(s) that can be charged with implementing monitoring and whose financial legitimacy and capacity will largely condition the sustainability of the monitoring.

> The outcome of this sixth stage is:
> (i) possible addition of principles and criteria deemed to be essential and "omitted" by the actors
> (ii) for each selected criterion, one or a list of a few indicators to measure or estimate the criterion
> (iii) the development of a preliminary proposal for a reporting mechanism and an institutional mechanism for indicator monitoring

Stage 7. Data inventory and indicator approval

It is important that the choices made when selecting and establishing indicators are discussed collectively both because the choice of indicators is not neutral strategically and politically and because it can be an opportunity to use actors' knowledge of existing monitoring systems. This collective debate is an opportunity to discuss not only the scope and the interest of the indicator but also the quality of the data, the calculation methods and the data requirements. Identifying the possible sources of data can be an opportunity to identify decentralised and/or non-institutional databases and hence, share whatever knowledge the different types of actor may have. Depending on the actors' support for the approach, some data could be shared. Discussions on calculation methods or on the relevance of some of the indicators can often clarify, in concrete terms, farming practices or regulatory systems. This stage can be organised as collective meetings or interviews.

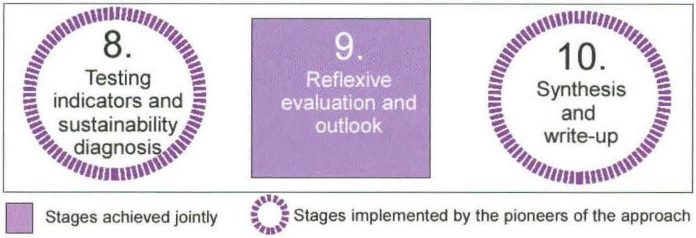
If the pioneering group wishes to avoid too many meetings and feels that this discussion stage is too close to the principle and criterion prioritisation working group and/or it is difficult to discuss indicators without first measuring them, the pioneering group may decide to postpone this task until stage 9, this being the reflexive evaluation. Discussions would then be based on the detailed presentation of indicators, their calculation methods and the initial results rather than on a list.

> The outcome of this seventh stage is:
> (i) identification of all data sources
> (ii) a proposed list of collectively agreed indicators

Phase 3. Validation phase

This last phase of assessment and final validation before implementation comprises three stages.

The three stages of the third phase



Stage 8. Measuring and testing indicators: undertaking a sustainability diagnosis

The suggested indicators must be measured in order to establish an initial diagnosis of the sustainability of the relevant aquaculture system(s).

Whether for institutional decision-makers or for the fish-farmers concerned, this diagnosis must be as detailed as possible by sub-zone and by type of farm, depending on the reference typology of the relevant aquaculture system (cf. stage 4), in order to facilitate the formulation of recommendations for accompanying actions in support of sustainable development.

This "technical" task is the responsibility of the pioneering group but it may be entrusted either to an external consultant or to the institution designated to implement monitoring. Chapter 6 details this crucial stage and offers some important recommendations concerning the ways to measure indicators and the reporting possibilities in order to facilitate communication of the results.

This is an initial test following which, for technical reasons, some indicators may be reformulated, replaced by similar ones or abandoned. Depending on the availability and commitment of participating stakeholders, the indicators suggested by the pioneering group can be validated before this trial phase. It must borne in mind that, due to their role as a standard, the definition of indicators can be controversial and therefore must be thoroughly discussed. This intermediate validation means that the measurement of indicators which would be rejected by the actors can be avoided. On the other hand, if validation is postponed until after the measurement, actors may better understand how indicators operate and their meaning before validating them.

> The outcome of this eighth stage is:
> (i) a final operational list of indicators post-test
> (ii) the production of a descriptive sheet for each indicator specifying its objective, its place and its evaluation methods
> (iii) an initial diagnosis of the sustainability of the relevant aquaculture system(s)

Stage 9. Reflexive evaluation and outlook

From the co-construction point of view, this stage also has an important, highly symbolic and decisive role for actors' collective learning. A collective workshop should be organised, the aim of which is to validate collectively the results of the approach and the final list of principles, criteria and indicators for the relevant aquaculture system(s).

On the basis of the propositions made by the pioneering group for reporting and sustainability, this workshop would also have the task of evaluating the technical and institutional feasibility of implementing the proposed monitoring system on a sustainable basis. Depending on the identified contexts and risks, this stage may also result in the identification of the necessary accompanying methods (awareness raising activities, institutionalisation, budgetary support, etc.).

Depending on the results of the participatory phases of the approach, this reflexive workshop may be an opportunity to discuss future possibilities and to formalise the conditions for the approach to evolve towards an institutionalisation of the group.

> The outcome of this ninth stage is:
> setting up a workshop for a collective evaluation of the results of the approach

Stage 10. Synthesis and write-up

Finally, it is the responsibility of the pioneering group to write a summary of the implementation of the approach, to present the results in terms of indicator systems (selected principles, criteria and indicators) and also to make a global assessment of the achievements and constraints and to make recommendations for an action plan to introduce the proposed monitoring system.

The outcome of this tenth stage is a summary report

Chapter 5
Introducing the reference framework for principles and criteria

The criteria suggested for each of the thirteen principles identified are listed. It is recommended to set up a standardised numbering system to facilitate classification and links between criteria and principles.

The criteria are deliberately simplified to help the memorisation process. They are complemented by a section containing observations specifying their scope. Two columns, respectively **S** for sector and **T** for territory (region), refer to the scales and specify whether a criterion refers to the sustainability of aquaculture farms and/or to the contribution that these systems make to the sustainability of the regions where they operate. The lists of indicators corresponding to each criterion (from 1 to 5 indicators) and to each type of approach to sustainability (sectoral and regional) are detailed in the appendix. A coloured background indicates which dimension of sustainable development the criterion refers to (environmental, economic, social, governance).

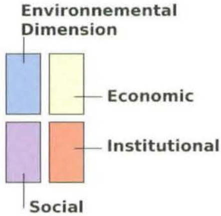
During the trial phase, these principles and criteria were prioritised for each of the aquaculture systems being studied. Criteria that were selected by at least four of the six regions are in bold. The fact that they are common to several aquaculture systems within a very mixed group of these systems leads to the conclusion that they are of a more general nature and can therefore be recommended whatever the context. Hence, they can provide a starting point for the development of the lists that will be established using this reference framework.

Criterion	Code	Heading	S	T	Observations
1	**P1C1**	**Importance of fish availability**	*		Quantitative contribution of the supply
2	**P1C2**	**Level of accessibility**	*		Social (price) and geographical (transport) destinations of the supply
3	**P1C3**	**Level of nutritional contribution**	*		Qualitative contribution of the supply
4	P1C4	Presence of xenobiotics	*		Health quality of products
5	P1C5	Importance of processing	*		Quantitative adaptation of capacity to demand

Principle no. 1 (P1) Contribute to fulfilling the nutritional needs of societies

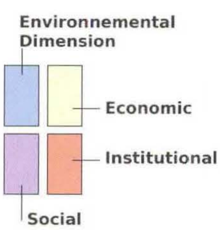
Criterion	Code	Heading	S	T	Observations
1	**P2C1**	**Existence of a quality-based approach**	*		Product labelling or certification scheme
2	P2C2	Existence of traceability	*		Traceability control at sectoral and value chain levels
3	P2C3	Level of value enhancement	*		Relative price of products, sector competitiveness
4	P2C4	Existence of segmentation	*		Diversification and specialisation in marketing
5	P2C5	Existence of appropriate processing capacity	*		Qualitative adaptation of processing capacity to companies' requirements.

Principle no. 2 (P2) Develop approaches which promote quality



Criterion	Code	Heading	S	T	Observations
1	P3C1	Importance of harvesting from fish stocks	*		Impact of fishing of juveniles and impact of catches for fish meal and oil supply
2	P3C2	Importance of water abstraction	*		Hydrological impact of the activity (reserved flows, use conflicts)
3	P3C3	Importance of space occupation	*		Impact on land in terms of occupancy and use conflicts
4	P3C4	Level of physico-chemical quality of effluents	*		Existence of water quality difference between inlet and outlet
5	**P3C5**	**Level of biological quality of effluents**	*		Existence of water quality difference between inlet and outlet
6	**P3C6**	**Respect for carrying capacity**		*	Production level compared to the environmental carrying capacity (often needs to be assessed)
7	**P3C7**	**Existence of management systems**		*	Access planning, conflict management, control of environmental impact

Principle no. 3 (P3) Ensure respect for natural resources and adaptation to the environmental capacity



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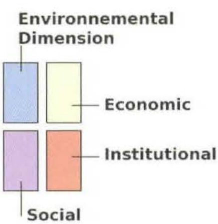
<tr><th>Criterion</th><th>Code</th><th>Heading</th><th>S</th><th>T</th><th>Observations</th></tr>
<tr><td>1</td><td>P4C1</td><td>Energy control</td><td colspan="2">*</td><td>Nature and level of energy used</td></tr>
<tr><td>2</td><td>P4C2</td><td>Level of productivity compared to resources</td><td colspan="2">*</td><td>Nature and level of natural resource consumption (water ...)</td></tr>
<tr><td>3</td><td>P4C3</td><td>Level of life cycle assessment (LCA) of the enterprise</td><td></td><td>*</td><td>Global approach to the environmental impact of the farming operation (these composite indices require specific methods which are described in box no13)</td></tr>
<tr><td>4</td><td>P4C4</td><td>Existence of by-product recycling</td><td>*</td><td>*</td><td>Filtering role in terms of mud and effluents</td></tr>
<tr><td>5</td><td>P4C5</td><td>Existence and selection level of strains</td><td>*</td><td></td><td>Conversion index, protein yield of the operation</td></tr>
<tr><td>6</td><td>P4C6</td><td>Polyculture level</td><td colspan="2">*</td><td>Enhancing value of the trophic chain</td></tr>
</table>

Principle no. 4 (P4) Improve the ecological yield of the activity

Criterion	Code	Heading	S	T	Observations
1	P5C1	Importance of genetic pollution		*	Escapement rate, species introduction
2	P5C2	Nature of farmed species		*	Native nature of farmed species
3	P5C3	Capacity to protect habitats		*	Relationship with and physical impact (degradation) on the natural environment
4	**P5C4**	**Nature of farming and slaughtering practices with respect to animals**	*		Overview of farming and slaughtering techniques / codes of best practice

Principle no. 5 (P5) Protect biodiversity and respect animal well-being



<table>
<tr><th>Criterion</th><th>Code</th><th>Heading</th><th>S</th><th>T</th><th>Observations</th></tr>
<tr><td>1</td><td>P6C1</td><td>Level of diversification</td><td>*</td><td></td><td>Species, product and market diversity</td></tr>
<tr><td>2</td><td>P6C2</td><td>Existence of innovations</td><td colspan="2">*</td><td>Frequency and type of past innovations</td></tr>
<tr><td>3</td><td>P6C3</td><td>Nature of the relationships with research and extension service</td><td colspan="2">*</td><td>Proximity and mechanisms for possible dialogue with technical and scientific advisers</td></tr>
<tr><td>4</td><td>P6C4</td><td>Level of economic dependence</td><td>*</td><td></td><td>Economic weight of inputs in the activity</td></tr>
<tr><td>5</td><td>P6C5</td><td>Supply control</td><td colspan="2">*</td><td>Dependence on feed, on fry, on water resources ... (quantity and quality); regulation for setting up hatcheries</td></tr>
<tr><td>6</td><td>P6C6</td><td>Control of site access</td><td>*</td><td></td><td>Constraints: physical (equipment), financial (land price), regulatory (duration of authorisations, installation procedures).</td></tr>
<tr><td>7</td><td>P6C7</td><td>Level of awareness of natural hazards</td><td>*</td><td></td><td>Exposure to storms, floods, accidental pollution, upwelling and diffuse pollution</td></tr>
<tr><td>8</td><td>P6C8</td><td>Level of awareness of pathological risks</td><td>*</td><td></td><td>Exposure to environmental risks (KHV,HSV,...)</td></tr>
<tr><td>9</td><td>P6C9</td><td>Insurance level</td><td colspan="2">*</td><td>Insurance practices and possibilities</td></tr>
</table>

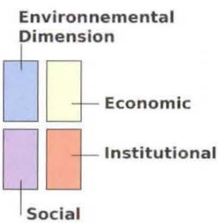
Principle no. 6 (P6) Increase the capacity to cope with uncertainty and crises

Criterion	Code	Heading	S	T	Observations
1	**P7C1**	**Level of value enhancement to products and factors**	*		Product competitiveness
2	**P7C2**	**Level of production costs**	*		Factor productivity and profitability, predator and mortality control
3	P7C3	Level of management	*		Accounting capacity and practices with respect to company management
4	**P7C4**	**Level of financial autonomy**	*		Level of debts and profitability
5	P7C5	Access to funding	*		Funding facilities and existence of loans at reduced rates
6	P7C6	Level of vertical integration	*		Diversity of company size and operating systems. Existence of a group, trader - company relationships
7	P7C7	Transfer capacity of companies		*	Mode of transfer, number of applications to begin an operation, average age of enterprises.

Principle no. 7 (P7) Strengthen enterprise long term future

Criterion	Code	Heading	S	T	Observations
1	P8C1	Average salary levels	*		Compliance with wage regulation and average salary
2	P8C2	Access to the system of social protection	*		Existence of, and membership rate with, social protection systems
3	**P8C3**	**Training level**	*		General training, apprenticeship and professional training
4	**P8C4**	**Importance of networks**	*		Existence of know-how exchanges, dynamic networks of associations
5	P8C5	Access to information	*		Level and type of access to professional information
6	P8C6	Image of aquaculture	*		Clear industry image and existence of product promotion actions
7	P8C7	Existence and weight of trade unions	*		Existence of systems (professional organisations and consular chambers), level of representation and importance of trade unions
8	P8C8	Capacity to take part in decision-making		*	Systems of consultation with trade unions and sector representatives and of dialogue for setting up standards and policies related to the sector

Principle no. 8 (P8) Strengthen the organisation and identity of the sector



Criterion	Code	Heading	S	T	Observations
1	**P9C1**	**Level of working conditions**	*		Working practices and duration, compliance with recommendations for decent work, social conflicts and accidents
2	P9C2	Level of protection and of trade union membership of the staff	*		Membership rate with trade unions, existence of work contracts, of appeal procedures
3	P9C3	Importance of women's access to the industry	*		Women's access to the industry and existence of a status acknowledging women's work
4	P9C4	Existence of equal pay for men and women	*		Salary gaps
5	P9C5	Access to information	*		Existence of systems to exchange, compare and circulate information between professionals
6	P9C6	Level of isolation and living conditions	*		Spatial distribution of companies, means of access, practices and standards concerning workers' housing

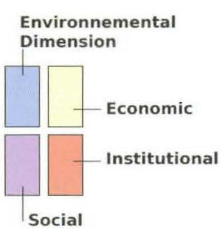
Principle no. 9 (P9) Strengthen companies' social investment

Criterion	Code	Heading	S	T	Observations
1	P10C1	Importance of development initiatives		*	Development of insalubrious zones, hydrological regulation or more generally positive impacts on ecosystems
2	P10C2	Importance of the wealth-building role		*	Enhancing the value of the built environment and contributing to local wealth
3	**P10C3**	**Level of contribution to local employment and to poverty reduction**		*	Contribution to employment and to local economy (strengthening the productive nature of zones where enterprises are located)
4	P10C4	Level of contribution to governmental budgets		*	Nature and importance of taxes paid
5	**P10C5**	**Level of contribution to local economy**		*	Synergy with other local activities (tourism, leisure, etc.) and support to pluriactivity
6	P10C6	Importance of the sector's environmental initiatives	*		Recycling of aquaculture by-products and use of aquaculture effluents and mud as agricultural fertiliser
7	P10C7	Capacity as environmental indicator		*	Warning system for environmental quality (watchdog role)
8	P10C8	Level of social recognition		*	Social recognition of the métier in the local community and inclusion in social networks (donations)
9	P10C9	Importance of the sector's local representation		*	Pro-active professional representatives in collective projects and in development mechanisms

Principle no. 10 (P10) Strengthen the role of aquaculture in regional development

Criterion	Code	Heading	S	T	Observations
1	P11C1	Level of comprehensibility of the industry		*	Existence of actions for communication, dissemination and training
2	P11C2	Existence of control systems		*	Nature and frequency of controls
3	**P11C3**	**Level of participation**		*	Existence of systems promoting implication, participation; dialogue and joint development of standards with stakeholders
4	P11C4	Level of decentralisation of decision-making		*	Capacity and practices for the local formalisation of international or national regulations
5	P11C5	Level of management and territorial planning		*	Existence of strategic plans for the spatial planning of aquaculture operations, providing them with legal security

Principle no. 11 (P11) Promote participation and governance

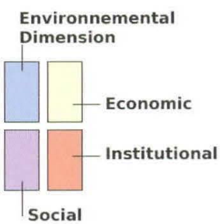


Criterion	Code	Heading	S	S	Observations
1	P12C1	Importance of research in aquaculture	*		Existence of laboratories, institutes or research bodies specialised in aquaculture research (natural and social sciences)
2	P12C2	Importance of training in aquaculture	*		Existence of institutes or bodies for specialised training in aquaculture
3	**P12C3**	**Level of interaction between research and industry**	*		Level of relationship between research activities and the sector's needs
4	**P12C4**	**Access to aquaculture information systems**	*		Nature and functionality of aquaculture-specific information systems (research and sector)
5	**P12C5**	**Access to scientific and administrative data**	*		Organisation and availability of data originating from research and from the administration responsible for the sector

Principle no. 12 (P12) Strengthen research and sector-related information

Criterion	Code	Heading	S	T	Observations
1	**P13C1**	**Level of national recognition of sustainable development**	*		Level of priority given to sustainable development in the State's objectives and public policies
2	**P13C2**	**Level of implication of the State in sustainable development**	*		Performance and competence of the State in putting sustainable development into place
3	**P13C3**	**Level of commitment of the State towards the industry**	*		Structuring and commitment of supervisory administrations, administrative systems, financial aids and specific financial arrangements, decentralisation of services
4	P13C4	Capacity of governance systems	*		Nature and efficacy of dialogue arrangements between the State and industry
5	P13C5	Familiarity with and local support to sustainable development (local agenda 21s)	*		Level of priority and implementation of sustainable development in objectives and public policies of regions and local authorities (local agenda 21s)

Principle no. 13 (P13) Strengthen the role of the State and of public actors in implementing sustainable development



Chapter 6
Focus on the methods used to measure indicators and report results

Measuring selected indicators involves a technical succession of actions. As previously highlighted in stage 6 concerning indicator selection, whenever possible, it is preferable to use an existing indicator or to suggest one already built from data which are already being monitored. This practice, which prevents the multiplication of the number of indicators, complies with the fundamental requirement of parsimony, which is recommended to reduce information collection costs, to promote sustainable monitoring, and to increase users' familiarity with the selected indicators. However, all indicators cannot be built from existing indicators or data. Once a list of indicators for each of the selected criteria has been established (stage 6), they must be measured in order to produce a diagnosis and set up monitoring. Figure 7 shows the succession of actions required.

6.1. Data collection and measurement or estimation based on expert opinion

The method used to measure indicators depends on their quantitative or qualitative nature and on the availability and reliability of necessary data. Data used to build indicators can come from several sources, including:

- existing institutional and standardised databases;
- specific data collection: surveys or centralision of information gathered from the different types of actors;
- construction of standard sectoral or regional accounts;
- estimations based on expert opinion.

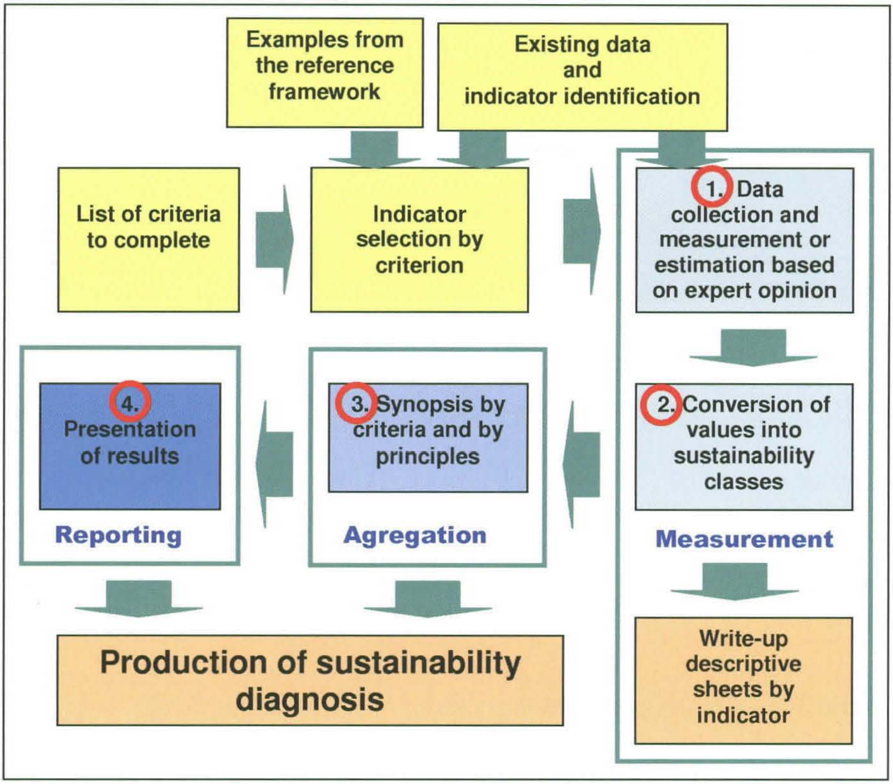


Figure 7. Breakdown of actions required to measure and report indicators

Due to their innovative nature, sustainable development indicators cannot always benefit from existing information systems. Moreover, data quality will also depend on the sector's and/or region's characteristics. In the case of a new activity, it is difficult to establish historical series and to obtain standardised data, as results are very heterogeneous and farming methods evolve rapidly during experimental phases. In the case of a traditional but informal operation, it is often difficult to access information, in particular when there is a large number of farms that are geographically widespread. In this case, a reference typology showing the heterogeneity of the aquaculture systems is essential. It is then recommended to establish standard accounts and/or undertake complementary surveys on the basis of this typology. These constraints are often found in economic data concerning the productivity and profitability of enterprises. When no accounting data are available, reference accounts should be established by type of farm. This practice may, however, be difficult in the case of pluriactive units where aquaculture is not the main activity. Given their cost, surveys can only be undertaken occasionally or with a frequency that is appropriate for monitoring the main structural changes. Table 6 seeks to summarise the types of problem found with respect to access to data and information.

Table 6. Typology of problems encountered and methodological responses with respect to information

Problems encountered	Possible solutions
Unavailable or unreliable data	Network of technical experts and cross-checking of information sources, monitoring of reference farms according to the typology
Qualitative data difficult to quantify	Evaluation based on expert opinion, through indirect survey using a correlated variable (notion of proxy)
No standardised collection method, calculation method, reference dates	Correspondence scale relating to a typology of methods
Brevity of the observation period, particularly when compared to the time of onset of some structural effects or threshold phenomenon	Indirect evaluation based on available elements or expert opinion Development of scenarii based on high and low hypotheses
Complexity of interactions between means and results and spatial heterogeneity of phenomena and dynamics	Some aspects merit attention: - observing a result does not necessarily mean that there is a link with an incentive measure or a particular practice - a practice can be efficient without necessarily leading to expected changes because of opposite effects due to other actions - the effects of a practice or a measure can be differentiated according to the sub-zones or sub-populations targeted.

For many variables, in the absence of data, it is usual to seek expert opinion. Such experts might be researchers, or those with institutional or professional responsibilities. This type of approach is very frequent for social indicators or for those relating to the contribution of farms to the regions where they are located.

Hence, the strategy adopted to measure indicators, or even to select them, given that their easy measurement is an important selection criterion, must be specific to each situation.

However, it must be stressed that it is not the measured value (the datum) that is the indicator, but rather its relative position on a scale indicating graduation thresholds or classes that express sustainable development. Hence, quantitative variables evaluated as numbers must then be converted into classes and into qualitative terms not only to qualify their position in terms of sustainability but also to obtain a homogenous evaluation of all the variables, regardless of their type, qualitative or quantitative, and their measurement methods, calculated or based on expert opinion. Therefore, this final approach by sustainability class leads to the recommendation that efforts should be focused on widening the range of measured indicators rather than improving the precision of actual measurements. Without, of course, being exhaustive or directive, some examples of possible measurement methods can be given according to the types of indicator.

Box 12
Examples of indicator measurement
1/3

The methods used to measure sustainable development indicators depend on the contexts with respect to access to information. Three main cases can be distinguished depending whether the measurement is based on:
1) existing data available from institutional bodies in charge of data collection (example: Eurostat, INSEE, consular chambers, local observatories,...),
2) data specifically collected through surveys, these being of varying significance and frequency according to the need for information and the resources available. For example much information can be collected during surveys of exploitation systems, interviews about perceptions (cf. appendix 2),
3) assessments based on expert opinion when data are not available (non-existent or unreliable) as often happens in the case of social and governance indicators. The opinion of experts then has to be relied upon. The evaluation should be carried out collectively by several experts and, when possible, combine both "scientific" and "field" experts.

These various measurement methods can be combined when developing composite indicators. They are illustrated by the four examples below. The indicators which relate to aquaculture systems in Brittany and Cirata (cf. § 7), include the four dimensions of sustainable development and are measured at farm level or at regional level depending on the case.

Indicator 1: Proportion of aquaculture jobs/productive jobs (P10C3)
This economic indicator can be used to evaluate the relative weight of aquaculture employment in a given region. This indicator is the result of the ratio between two other

indicators which are usually available. It depends on the relative importance of the activity within the productive system of the region, i.e. the significance of the aquaculture sector will be assessed according to the extent of its geographical distribution and the importance of other structuring activities. Data availability permitting and depending on the rural or urban nature of the area, it is recommended that the reference to global employment should exclude local activities linked to services rendered to the population and concentrate on employment generating direct value-added. This indicator must be measured both at local and national levels.

Box 12
Examples of indicator measurement
2/3

In Brittany, this ratio was obtained by mixing several databases from: the chamber of commerce, URSSAF ("Union pour le Recouvrement des cotisations sociales de la Sécurité Sociale et des Allocations Familiales" - Union for the collection of social security and family allowance contributions) and ANPE ("Agence Nationale Pour l'Emploi" - job centre). Some 1,500 aquaculture jobs were found in a total of 177,000 productive jobs in Brittany, which means that 1% of total productive employment is linked to aquaculture. The conversion into sustainability classes is carried out by comparison with the weight of other activities, and in the case of Brittany, this ratio is rather low compared to the importance of agriculture and agro-alimentary industries. The score is therefore equal to 1.

Method	Source	Unit	Sustainability scale	Score
Indicator calculated from existing data	Chamber of commerce, URSSAF, ANPE	%	>80% = 5pts] 50%, 80%] = 4pts]20%, 50%] = 3 pts]5%, 20%] = 2pts ≤ 5% = 1pt	1 pt

Indicator 2: Energetic yield (P4C1)
This environmental indicator can be used to calculate aquaculture farms' annual energy consumption. The objective is to show the ecological yield at the levels of the farm and the region as a function of consumption practices and the types of energy used (renewable or not). Several calculation methods can be used. In the case of Brittany, it is equal to the ratio of annual consumption of purchased energy (megawatt-hour, diesel or petrol, natural gas, gas cylinder, fuel, electricity and liquid O2) to fish production in tonnes.

The sustainability score must be selected in relation to the productive system which may use more or less energy depending on its intensification and productivity levels. In the case of Brittany, where the production system is intensive, energy requirements are high but production is also high.

Method	Source	Unit	Sustainability scale	Score
Enterprise accounting data	Producer	MWh/ tonne	≤ 2 = 5pts] 2, 5] = 4pts]5, 10] = 3 pts]10, 50] = 2pts > 50 = 1pt	5 pts

Indicator 3: Dialogue mechanisms between State and industry at national, regional and local levels (P13C4)

This governance indicator can be used to determine the intensity and the quality of the relationships between the State (and the local authorities) and the aquaculture industry at different scales (national, regional and local). Its measurement is based on expert opinion with respect to the role of the State and public actors in putting sustainable development into place and the sector's involvement in decision-making and public policies in order to show the level of participation.

Box 12
Examples of indicator measurement
3/3

In Cirata (Indonesia), this expert-based evaluation took into account the presence of several mechanisms. The importance of each of these mechanisms and the way in which they operate must be assessed. Development service units created by farmers comprise elected members that represent the sector at local government or province level. In addition, supervisory, dissemination, field facilitation and intermediation services create links between national and local levels.

Method	Source	Unit	Sustainability scale	Score
Expert opinion	Local researchers	Qualitative	Very important=5pts Important =4pts Satisfactory =3pts Poor=2pts Non-existent =1pt	5pts

Indicator 4: Importance of fish availability: contribution of supply from a nutritional point of view (P1C1)

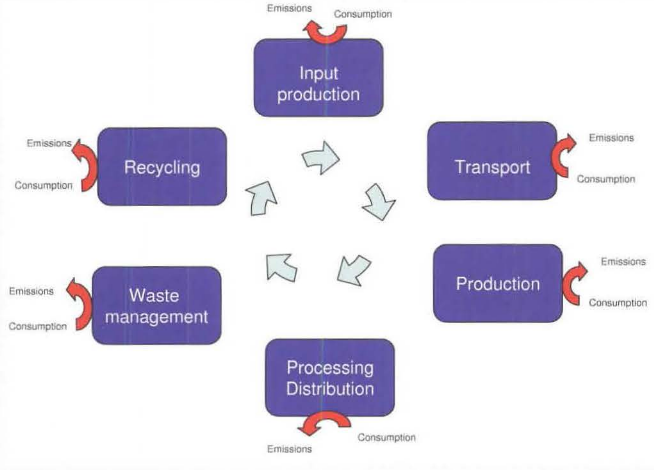
This social indicator reflects the significance of fish availability when it comes to meet the nutritional needs of local populations. In Cirata, its calculation is based on the ratio of the province's aquaculture production to the theoretical production necessary to fulfil the province's consumers' needs in inland aquatic products (estimated as the annual consumption of fish, in kg, per inhabitant x the number of inhabitants in the province x the percentage of freshwater fish production in the total production of aquatic products).

Method	Source	Unit	Sustainability scale	Score
Surveys; existing production data	National statistics, producers, Fish Stat	%	> 10% = 5 pts] 10, 7] = 4 pts] 7, 4] = 3 pts] 4, 1] = 2 pts <1= 1pt	5pts

Life Cycle Assessment (LCA) is a method used to analyse potential environmental implications, input consumption and polluting discharges associated with a product or a service, during its entire life, from the time it is extracted as a raw material, throughout its use and until the time it is discarded or recycled. It operates within the framework of the ISO 14000 environmental management standards.

This method has been applied to agriculture since the end of the 1990s (since 2002 in aquaculture) and continues to be developed. It is based on the calculation of a group of indicators, called impact categories, which cover the main environmental issues and can be applied at different spatial scales: local, regional or global. These impact categories are calculated by aggregating the different products generated or consumed, proportionally to their potential polluting activity.

Box 13
LCA, Life Cycle Assessment
1/2



In the field of aquaculture, impact categories commonly used are the following:

- eutrophication, expressed in kg of phosphate equivalent (kg PO4-eq), which evaluates the potential degradation of the aquatic environment due to the dumping of (nitrogenous and phosphorated) nutrients which cause algal proliferation using up available oxygen;
- acidification, expressed in kg of sulfur dioxide equivalent (kg SO2-eq), which evaluates the potential acidification of ground and water due to the production of acidifying molecules in the air, the ground or the water;
- climate warming, expressed in kg of carbon dioxide equivalent (kg CO2-eq), which evaluates the production of greenhouse gases by the system ;
- the use of energy, expressed in megajoules (MJ), which encompasses all the energy resources used;

Box 13
LCA, Life Cycle Assessment
2/2

- the use of net primary production, expressed in kg of carbon (kg C), which reflects the pressure on the trophic chain through the evaluation of the amount of carbon derived from the photosynthesis necessary to produce one unit of weight of the relevant animal;
- water dependency, expressed in m3, which indicates the water used or the water which passes through the farming system during production in the case of aquaculture.

All these impact categories are calculated with respect to a functional unit which is usually the produced tonne... In some cases, it may be of interest to use surfaces as functional units, for example in the case of fish ponds.

The use of LCA in sustainability analyses of agricultural and aquaculture systems is of interest in numerous ways. The method can be used to define and formalise the production system, its different parts, its limits and the flow of materials it depends on or produces. LCA is useful to move beyond a local perception of environmental issues. The various impact categories can be used to encompass all the interactions with the environment and to analyse the relationships between impacts. Taken separately, impact categories can also serve as indicators and enrich systems of social, economic, environmental and governance sustainability indicators.

For further information on LCA in aquaculture:

Aubin J., Papatryphon E., Van der Werf H.M.G., Chatzifotis, S., Assessment of the environmental impact of carnivorous finfish production systems using Life Cycle Assessment, J. Clean Prod, 2008, in Press.

Jolliet O., Saadé M., Crettaz P. Analyse du cycle de vie, 2005. Comprendre et réaliser un écobilan. Lausanne, Suisse : Presses Polytechniques et Universitaires Romandes, 242 pp.

Papatryphon, E., Petit, J., Kaushik, S.J., Van der Werf, H.M.G., 2004. Environmental impact assessment of salmonids feeds using Life Cycle Assessment. Ambio. 33: 316-323.

Pelletier N.L., Ayer N.W., Tyedmers P.H., Kruze S.A., Flysjo A., Robillard G., Ziegler F., Scholz A., Sonesson U., 2007. Impact categories for Life Cycle Assessment research of seafood production systems: review and prospectus. Int. J. LCA 12 (6): 414-421

6.2. Conversion of values into sustainability classes

Indicator measurement is based on the transformation of all quantitative and qualitative data into classes organised in increasing order with respect to sustainability objectives.

The number of classes can vary, usually five classes ranging between 1 (minimum) and 5 (maximum) are used. A score of 1 is preferable to 0 which could be badly perceived. Five classes offer a scale with a satisfactory scope, whilst being compatible with the more familiar scales of 10 or 20. In some survey- or expert-based estimations, it is possible to ask for a score out of 10 or 20 and then to convert the results into the reduced scale of the five classes. This can facilitate the evaluation. A significant pitfall of five-class scales must be highlighted, which is that the median value of 3 is often selected preventing discrimination in the results. Therefore it is important either to avoid this median class or else to use an even number of classes (4 or 6 for example).

Whatever the number of classes, the creation of a scale of sustainability classes requires that much thought be given to the threshold values that define these classes. This approach demands that the question be posed as to what is and what is not sustainable. This leads again to the political and normative significance of the indicator and it is important in the final validation with the actors that the choices made be clearly presented to them according to the grounds on which they are based, and that they be discussed. In some cases, these operations must be carried out in cooperation with the actors and it is recommended that the pioneering group, depending on its composition, benefit from the technical skills of specialised experts in this task. They can be specialised in water quality, production techniques, socio-economic aspects, governance, etc.
Depending on the case, the choice of these thresholds is guided by different approaches. For example, the issue might be to observe the distribution of a continuous variable and establish statistically significant classes. In this case, a class should never cut across the mode(s) of a distribution but, on the contrary, classes should aim to organise the distribution by isolating very low, low, average, high and very high values. Class thresholds can also be defined directly on the basis of expert opinion. In this case, the evaluation should be carried out as collectively as possible.

In order to facilitate understanding of the results, the indicator should be calculated so that classes always follow an ascending order with respect to sustainability objectives. In cases where low values of the indicator - for example for discharges or pollution - indicate a favourable situation, the reasoning must be reversed in order to maintain ascending classes, for example to measure the escapement rate of the livestock or the weight of active particles compared to production. In some cases, the same indicator can vary in different directions depending on the relevant principles and dimensions of sustainable development. Hence, for example, the salary level is seen as positively ascending from a social point of view or from the contribution it brings to the region whilst it can be a constraint on enterprise profitability in some cases.

All the calculation principles, the data sources and the classification methods with respect to sustainability objectives must be precisely noted and accompany the presentation of indicators. It is therefore common practice to establish descriptive sheets which show concretely how each of the indicators was developed. Usually, these sheets, a model of which can be found in the appendix, comprise sections which include some or all of the following points:

- the indicator classification with its code and its relationship to criteria and principles;
- data sources, their terms of use and possibly data collection or access costs;
- the scale and frequency of the measurement;
- the type or category of indicator (for example, state, pressure, response, etc.);
- the dimension(s) of sustainable development the indicator refers to;
- the meaning of the indicator and the interpretation of its variation;
- relationships with other data or indicators;
- the objective to be achieved with respect to sustainable development.

These sheets relate to the situation of the information systems and depend therefore on a given situation. They are a kind of meta-database of indicators.

6.3. Synopsis and aggregation by criteria and by principles

Monitoring the set of indicators provides a useful dashboard for decision-makers, managers and producers in its basic configuration, as it enables a detailed diagnosis of the situation to be made. However, once indicators are numerous, it becomes difficult to discern the overall picture to establish a diagnosis by zone, by type of operation or by type of aquaculture system. Synopses by criteria and even by principle should therefore be provided. Figure 8 suggests how the aggregation might be made, but this method is not compulsory.

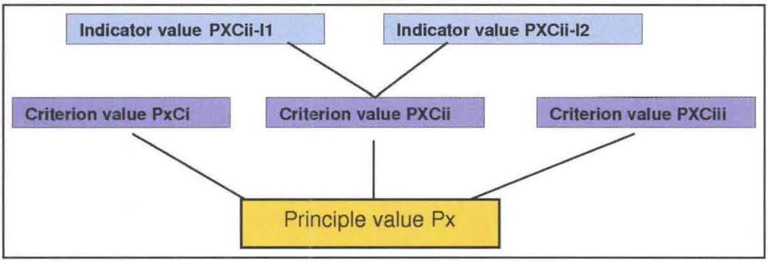


Figure 8. Indicator and criterion aggregation method

Several important recommendations must be taken into account when undertaking the tricky task of aggregating indicators, if this is thought to be necessary.

First, it is preferable not to use a single criterion by principle and a single indicator by criterion, but rather to enrich the tree diagram in order for the diagnosis to be as balanced as possible and to make sense to a larger number of actors, each of them being affected by different types of criterion and indicator. This requirement must, however, be balanced by another requirement which is just as important, the parsimony of criteria and indicators, which means that, in order to facilitate the appropriation and sustainability of the monitoring system, the number of criteria and indicators must be limited. Hence, a small system, for example between 15 and 20 indicators, cannot satisfy all the stakeholders if they are numerous. A number of criteria and indicators ranging between thirty or forty promotes diversity and is still easy to manipulate. On the other hand, more than eighty indicators pose real working problems.

Indicator aggregation at the scale of criteria. Two methods of analysis are possible to summarise indicators by criteria which are then also classified on the same scale as the indicators (from 1 to 5 for example). The most common approach is to use the average value of the indicators corresponding to each criterion. In this case, the key question is whether to use a simple average or a weighted average, which would then mean that weighting coefficients would have to be defined. It should be recalled that the absence of weighting is not neutral but amounts to attaching the same importance to all indicators. When defining weighting coefficients, the relative importance of factors compared to sustainability objectives must be discussed, in particular with the actors given the very "political" nature of the choices that are made. A consensus must be reached about these coefficients as they will play a decisive role. A summary table listing the strengths (positive sustainability values) and weaknesses (negative sustainability values) of each of the criteria must accompany the synoptic diagnosis based on average data, in order to see how the various components contribute to these average values. Whether weighted or not, as for any mean, its significance depends on the standard deviation of the values on which it is based. It is therefore vital that during the analysis the results remain comprehensible, even if it means making some adjustments to the process. Hence, if the indicators relating to the same criterion have opposite values, for instance one scores 1 and the other 5, this criterion should be split into two criteria to maximise significance or else only the most relevant or reliable of the indicators should be retained. This type of adjustment can only be made on a case-by-case basis depending on the results' profiles, the number of indicators relating to the criteria and the number of criteria. The other practice, which is less common, consists of using the lower indicator value rather than the average. This method is based on the idea that sustainability is limited by the highest constraint.

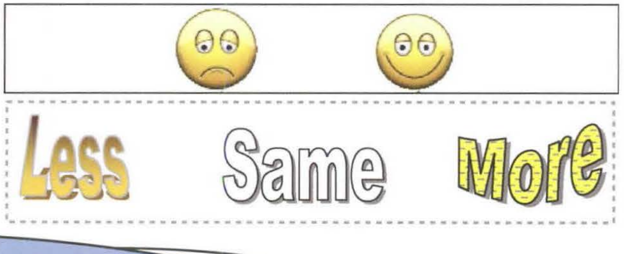
Aggregation of criteria according to principles. Whilst it is generally indispensable to aggregate indicators by criteria, this is not usually necessary in the case of the principles or the sustainable development dimensions. If the method used to present the results allows the comparison of a significant number of indicators, a diagnosis can be established at the criterion level. They can then be simply pulled together by dimension, by principle or by group of principles depending on the issues and the number of criteria relating to the principles. The adopted strategy depends on the number of criteria and on the objectives and types of actors who will use these indicators. Hence, it may be useful to compare the performance of aquaculture systems with reference principles or with the four dimensions of sustainable development given the educational nature of these synopses. In this case, the same techniques and recommendations as those presented for criterion-based indicator aggregation apply. It should be noted that specialised software is available to undertake these aggregations (Box 14).

Box 14
Example of the DEXi software

DEXi is software developed by the Department of Knowledge Technologies of the Jožef Stefan Institute and by the University of Maribor (Slovenia). It is available as freeware on the internet: http://www-ai.ijs.si/MarkoBohanec/DEXi.html
It has two complementary features, allowing: (1) the development of multi-criteria qualitative models and (2) the application of these models to the evaluation and analysis of multi-attribute decision-making. DEXi is a decision modelling tool enabling multi-criteria evaluations of different options. Models are defined from (1) attributes (qualitative variables), (2) an ordered or unordered scale of values, (3) an attribute tree (a hierarchical structure) and (4) utility functions (rules that define the aggregation of attributes from the bottom to the top of the attribute tree). In our case, the attributes are in fact indicators which, once measured using a selected scale (from the lowest 1 to the highest 5 degree of sustainability) can be aggregated by criterion. Criteria can then be aggregated by principle and principles by dimension and even allow the calculation of a global sustainability index. These aggregations are calculated from a pre-defined utility function ideally developed in cooperation with the actors or according to the preferences they expressed during the PCI prioritisation and selection stages (see stages 6 and 7).

6.4. Presentation of results

Various types of graphical representation can be found as shown in the figure 10 which gives some examples. Most of the time, sustainability levels are indicated by colours or by graph areas, sometimes the results can be expressed simply in terms of pictograms such as the one below, by mathematical symbols (--, -, =, +, ++) or by arrows to indicate dynamic trends.



The choice of these presentation and reporting methods is crucial in terms of communication and use. It must be adapted to the context and profile of future users. Choices must also take into account for example literacy levels, work and presentational habits. Of course, they must be discussed and tested.

The radar or kite graph (figure 9) found in spreadsheet software is the most common and simple presentation used. It enables fast visual understanding of different situations, allowing comparisons of sustainability levels to be made quickly by bringing together quite a large number of axes and by facilitating the identification of critical points. It is therefore particularly appropriate when wishing to avoid aggregations. This type of presentation is therefore to be recommended for these properties but its use must be tested, as although common in the field of sustainable development indicators, it is not necessarily commonly known by actors. In the case of the guide, it is of interest because it enables all the principles to be presented in the same diagram, as shown in the Brittany illustration below, an example which is developed fully in the next chapter.

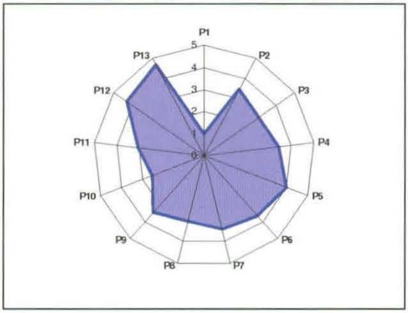


Figure 9. Illustration of a radar-type graphical presentation

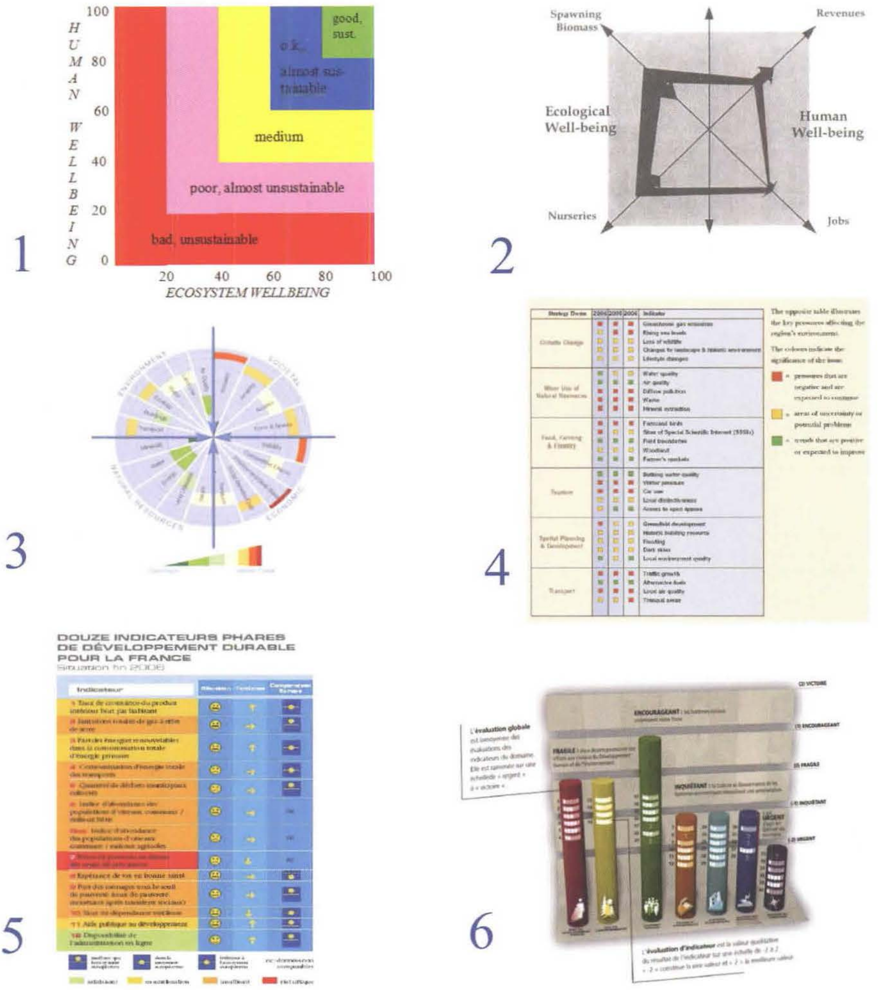


Figure 10. Examples of sustainability indicator presentations

1. Prescott-Allen's barometer
   http://www.eoearth.org/article/Indicators_of_sustainable_development
2. Fisheries sustainability evaluation. FAO
   http://www.fao.org/docrep/w4745e/w4745e0f.htm
3. Sustainable Project Appraisal Routine by ARUP 2004
   http://composite-indicators.jrc.ec.europa.eu/S10_visualisation.htm
4. Environmental indicators for the South West of Great Britain
   http://www.swenvo.org.uk/indicators/indicators.asp
5. 12 key sustainable development indicators for France
   http://www.ecologie.gouv.fr/3-Indicateurs.html
6. Dashboard indicating the situation in the Saguenay-Lac St Jean region
   http://www.tableaudebord.org/accueil.htm

Chapter 7
Two examples of diagnoses of aquaculture system sustainability

The EVAD research project (box 1) made it possible to test the suggested joint approach to building sustainability indicators within the framework of several types of very diverse aquaculture systems in terms of environments, intensification level of production systems and institutional contexts. Only two of these applications are presented here as examples. The two aquaculture systems selected are: the production of rainbow trout in basins in the Brittany region (France) and the production of both carps and tilapias in floating cages on the lake of the Cirata dam (Indonesia). They illustrate two aquaculture systems, one situated in a developed country and the other in a developing country. These diagnoses are based on a joint building approach involving fish-farmers and aquaculture stakeholders within each region. In each case, the pioneering group of the approach comprised researchers from the EVAD project and local partners namely:

- the "Comité Interprofessionnel des Produits de l'Aquaculture" (CIPA) (Interprofessional Committee for Aquaculture Products) and the "Institut Technique de l'Aviculture et l'élevage des petits animaux (ITAVI) (Technical Institute for Aviculture and small animal husbandry) for Brittany.
- the Research Center for Aquaculture (RCA) and the Directorate General for Aquaculture (DGA) for Cirata.

In each of these examples, the way in which the suggested procedure was implemented is briefly presented together with the diagnosis established from the jointly built sustainability principles and criteria.

7.1. Methods used to establish the diagnoses

The lists of principles, criteria and indicators used to establish the diagnosis of the dual nature of Breton and Indonesian aquaculture systems were obtained by combining the principles, criteria and indicators specific to each of these systems with the principles, criteria and indicators common to four out of the six EVAD aquaculture systems (box 1) where the method was tried. The latter were recommended for their universal nature. The tables below show the principles and criteria selection and validation methods tried for each of the studied aquaculture systems (table 7) and the resulting number of principles, criteria and indicators (table 8).

Table 7. Presentation of the methods used to select and validate the sustainability principles and criteria in the studied aquaculture systems

	Brittany	Cirata
Selection phase	The selection was based on questionnaires completed individually within the framework of several meetings (by sub-zones) which producers and other actors attended (separately because of some tension). Principles and criteria were selected independently of one another, the former first.	The selection was carried out collectively within the framework of focus groups conducted in Indonesian, over one day, and attended by some thirty actors. The selection was carried out within sub-groups of different types of actors, then results were pooled during discussions and role-playing which encouraged actors' participation, regardless of status.
Validation phase	Validation was carried out during a meeting involving several types of actor (producers, teachers, suppliers, consulting companies). Nevertheless, the rather low number of participants meant that they worked in a manner similar to an expert group.	Validation was carried out within the framework of a focus group comprising fish-farmers, alevin producers, fish wholesalers, feed retailers as well as the representatives of various institutions involved in overseeing aquaculture activity.

The sustainability diagnoses were undertaken at the scale of the criteria corresponding to the most relevant analytical level to evaluate the sustainability factors of aquaculture systems. To improve clarity, they were organised according to the four dimensions of sustainability (environmental, technico-economic, social and governance) and according to the principles to which they relate. The aggregation of indicators by criteria, then by principles or dimensions of sustainable

Table 8. Origin of the principles, criteria and indicators used for the sustainability diagnoses

	Principles	Criteria	Indicators
Specific to Brittany	9	38	42
Total – Enterprise sustainability in Brittany	9	24	32
Total - Contribution to regional sustainability in Brittany	10	30	34
Specific to Cirata	12	38	55
Total – Enterprise sustainability in Cirata	10	31	47
Total - Contribution to regional sustainability in Cirata	9	23	34

development was carried out on the basis of an unweighted average. When the results from indicators relating to the same criterion or from criteria relating to the same principle differed by more than 2 points, a specific comment was formulated. It should be noted however, that at the scale of criteria, aggregation was simplified by the fact that a significant number of criteria only related to one indicator.

In order to refine the analysis of both aquaculture systems, sustainability diagnoses address successively aquaculture farm sustainability and aquaculture's contribution to the host regions. Aquaculture farm sustainability was analysed according to the different types of enterprise. These (table 7) derive from aquaculture system typologies established prior to building indicators during the initial diagnosis (stage 4 of the procedure). Nevertheless, in the case of Brittany, the small number of farms in this region means that not all types are relevant. Only types 1 and 4, the most differentiated, are included. Indicator measurement usually reflects the average situation observed at enterprise level, all farms having been surveyed. On the other hand, the analysis of aquaculture's contribution to its host region is carried out globally at regional level, irrespective of the type of enterprise, and is often based on expert opinion.

Table 9. Types of aquaculture farms

	Brittany	Cirata
Type 1	Small units (< 100 tonnes) socially integrated with independent and diversified marketing	Small family units of 4 to 40 cages owned by the farmer, no salaried employees and no marketing activity.
Type 2	Same characteristics as type 1 enterprises but higher production level. (Average to large units >100 t)	Small units of 35 to 135 cages owned by the farmer (sometimes partial management), no salaried employees and no marketing activity.
Type 3	Average or large size units (>100 t), socially integrated, marketing linked to processing groups.	Large units of 80 to more than 170 cages, operated fully or partially by salaried managers and generally integrated upstream and downstream within the value chain (alevin production, marketing).
Type 4	Large units (> 200 tonnes) owned by people outside the social community, marketing dependent on processing groups.	

7.2. Sustainability diagnosis for trout farming in Brittany (France)

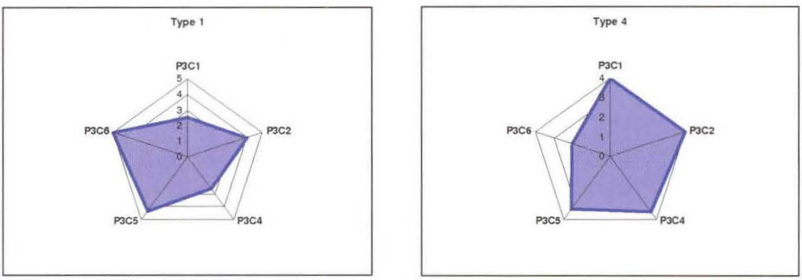
Trout aquaculture in Brittany has seen many changes during the last fifteen years, from a golden age to a period of decline with the loss of half the production volumes and sites. This trend reversal is due to a crisis caused by the conjunction of several factors. Whilst the lack of cohesion within the industry did not facilitate dialogue with the administration, the inclusion of environmental constraints led to stricter regulations and the closure of many production sites. At the same time, significant price fluctuations due to increased European competition, together with the fact that aquaculture products have become commonplace, led to mergers and to greater integration. In response to this crisis, regional association structures and the environmental side of farming (feed, filters, oxygenation, selection, vaccination) have improved.

<u>Farm sustainability</u>

The results of the evaluation of sustainability criteria were analysed according to sustainable development dimensions (figures 11, 12 and 13).

Given the highly-contrasting nature of the situations depending on the types of farm and given the low number of farms which increases the impact of individual strategies, it was not appropriate to undertake an overall average diagnosis of aquaculture farm sustainability. A comparative analysis was therefore undertaken of the two relevant types of enterprise which represent respectively small (type 1) and large (type 4) operations .

The environmental dimension of farm sustainability was analysed using 5 criteria relating to the level of marine fish catch and water abstraction, the quality of effluents and more generally the respect for the carrying capacity of the environment evaluated on the basis of expert opinion (figure 11).

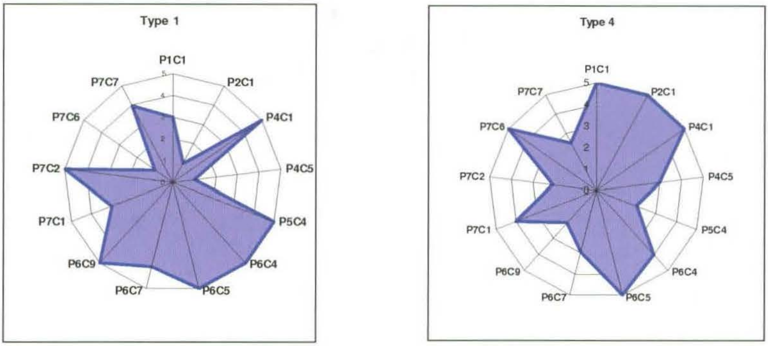


P3C1 Marine fish catch – P3C2 Water abstraction -
P3C4 Physico-chemical quality of effluents - P3C5 Biological quality of effluents –
P3C6 Respect for carrying capacity

Figure 11. Environmental sustainability of Breton aquaculture farms

The evaluation of environmental sustainability according to farm type tends to show, over and above the contrasting nature of the results, that large farms perform better (type 4). They tend to have only one critical area which is the relatively weak adaptation of production to the carrying capacity, although the quality of effluents remains positive and complies with standards. Small farms, better adapted to the environmental carrying capacity, have two weaknesses: the level of fishing of the resource for feed is significant due to a poor feed conversion ratio (P3C1), and a relatively low physico-chemical quality of effluents (P3C45), although it complies with standards. This situation results from the importance of treatment products, the water quality at the point of entry and the presence of Fario trouts, another trout species, in these farms which undertake both direct selling and stock enhancement.

The technico-economic dimension of farm sustainability (figure 12) is the one where the number of selected criteria is the highest (13 criteria). This concentration testifies to the significance of economic factors and of farming control in the way that sustainability is perceived, in particular by producers.

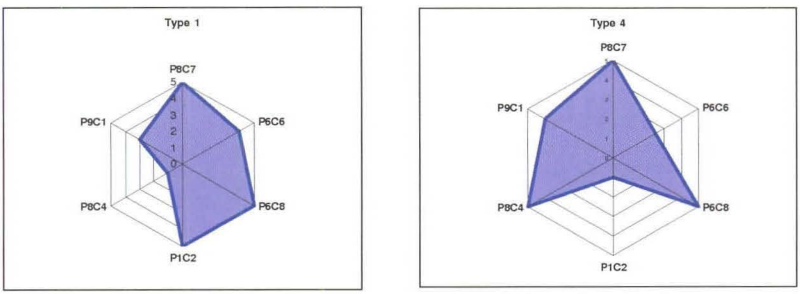


P1C1 Fish availability – P2C1 Existence of a quality approach – P4C1 Energy control – P4C5 Existence and level of strain selection – P5C4 Farming and slaughtering practices – P6C4 Level of economic dependence – P6C5 Control of supply – P6C7 Sensitivity to natural risks – P6C9 Financial autonomy – P7C1 Value enhancement of products and factors – P7C2 Level of production costs – P7C6 Level of vertical integration – P7C7 Transfer of enterprises.

Figure 12. Technico-economic sustainability of Breton aquaculture farms

Here also, the evaluation of farms' technico-economic sustainability attests to the contrasting results of different types of farm with respect to the nature of the criteria promoting or restricting their sustainability. On the other hand, it seems that generally, each type obtains quite similar scores with half the criteria favourable to sustainability and a quarter of them restricting it. However, the level of constraint is slightly lower for large farms which do not have a single score of 1 (against three criteria scoring 1 in small enterprises). The scoring detail according to the types of criteria characterises different sustainability profiles according to types. The advantages of type 1 operations stem from their financial autonomy (P6C9) which is partly related to the control of production costs (P7C2) and to a good expenditure-to-income ratio (P6C4), and which enables the passing on of farms (P7C7). On the other hand, they suffer from the absence of product labelling schemes (P2C1) and genetic management (P4C5) which does not correspond to the characteristics required for their outlet of fish re-stocking for recreational fishing. Conversely, type 4 farms turn out to be highly integrated (P7C6) and productive (P1C1) whilst knowing how to adopt ecolabels or quality charters (P2C1). Given the highly intensive nature of production, these farms face constraints concerning production costs (P7C2), financial autonomy (P6C9), risk sensitivity (P6C7) and mortalities (P5C4).

At the enterprise level, few criteria relating to the social and institutional dimensions were selected and these two dimensions were therefore merged (figure 13). If awareness of these dimensions is poor at the farm level, it is very high concerning the contribution of aquaculture to the sustainability of host regions, with most of the selected criteria concerning the governance dimension.



P8C7 Existence and importance of professional associations – P6C6 Control of site access – P6C8 Sensitivity to pathological risks – P1C2 Local fish accessibility – P8C4 Importance of networks – P9C1 Working conditions.

Figure 13. Social and institutional sustainability of Breton aquaculture farms

Two criteria have identical scores for the two types of farm and strengthen sustainability: organisation into professional associations (P8C7) and pathological risks (P6C8). These criteria relate to factors which go beyond the farm level. Apart from these criteria, each type has broadly two specific criteria that are unfavourable to farm sustainability and two that are favourable. In small farms (type 1), unfavourable criteria are the working conditions (P9C1) and the structure of professional networks (P8C4). The advantages of this type of farm which focuses on fish re-stocking for recreational fishing and direct selling come from their significant local social integration. The sustainability of large farms (type 4) which export their production outside the region and whose land requirements are significant is restricted by poor fish accessibility at the level of the region (P1C2) and by institutional difficulties related to the necessary authorizations. On the other hand, these large farms offer better working conditions to their employees (P9C1) and benefit from professional networks and from shared resources through the (private or co-operative) groups to which they are affiliated (P8C4).

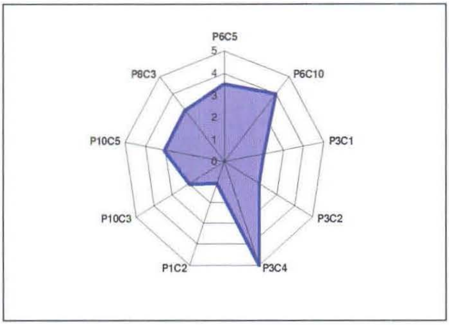
Following this analysis by criterion, it is possible to produce an overview of the main strengths and constraints in terms of farm sustainability (table 10).

Table 10. Summary of strengths and weaknesses of Breton farm sustainability

	Type 1	Type 4
Favourable factors	Good environmental integration Respect for fish well-being Economically healthy Absence of problems concerning production rights Good local integration of the production	Very good productivity (energy, feed) Sharing resources (marketing in particular) Marketing using product specification Decent working conditions
Unfavourable factors	Demanding working conditions Poor ecological yield (feed conversion) No genetic monitoring No specifications for stock enhancement	Average environmental integration but complying with standards No local sales Administrative problems with production rights Poor financial autonomy

The contribution of aquaculture to the sustainability of the region

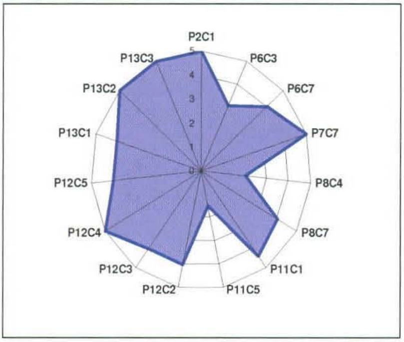
The distribution of the criteria selected for this approach relates mainly to the governance dimension. Hence, the criteria relating to the environmental, economic and social dimensions are presented first as a group (figure 14), followed by those relating to the institutional dimension (figure 15).



P6C5 Control of supply
P6C10 Level of insurance
P3C1 Marine fish catch
P3C2 Water abstraction
P3C4 Physico-chemical quality of effluents
P1C2 Farmed fish accessibility
P10C3 Contribution to local employment
P10C5 Contribution to local economy
P8C3 Level of training

Figure 14. Environmental, economic and social contribution of aquaculture to the sustainability of the region

The best score as regards aquaculture's contribution to environmental, economic and social sustainability in the region concerns the physico-chemical quality of effluents, related to compliance with waste disposal standards and to the moderate use of dangerous products. Generally, the recorded scores are rather low and reflect the limited contribution of aquaculture to the region's sustainability. In particular, both marine fish catch (P3C1) and water abstraction (P3C2) are unfavourable respectively because of the high feed concentration in proteins and oil of marine origin and because of the difficulty in consistently respecting reserved flows. Likewise, aquaculture's economic and social contribution to employment, to training and more generally to the local economy is limited (P10C3) especially compared to other agro-alimentary sectors.



P2C1 Quality-based approach
P6C3 Relationships with technical advisers and research
P6C7 Risk sensitivity
P7C7 Transfer of enterprise
P8C4 Importance of networks
P6C7 Importance and weight of professional associations
P11C1 Comprehensibility of the industry
P11C5 Regional planning
P12C2 Training in aquaculture
P12C3 Research-industry interactions
P12C4 Access to information
P12C5 Access to scientific data
P13C1 Recognition of Sustainable Development
P13C2 State involvement in SD
P13C3 State commitment towards the industry

Figure 15. Contribution of aquaculture to the sustainability of the region from the governance viewpoint

On the other hand, at local governance level (figure 15), it seems that aquaculture's contribution is both significant and relatively balanced between the fifteen selected criteria. Nevertheless, three critical areas emerge:

- poor management and regional planning (P11C5) reflecting the need to set up special zones for freshwater aquaculture, a request which is frequently mentioned by the industry,
- weak socio-technical networks (P8C4) despite a strong professional association structure (P8C7) and the presence of research institutes and training centres for aquaculture,
- and to a lesser extent, the nature of the relationships between research and the technical support system (P6C3).

On the other hand, compared to other regions in the world, the State's involvement in Brittany is significant with local representatives who are aware of sustainable development issues (P13C2, P13C3). These are favourable factors which should help to develop sustainable aquaculture and, in particular, the establishment of new enterprises.

Overall, this analysis enables the identification of favourable and unfavourable factors in aquaculture's contribution to regional sustainable development.

Table 11. Summary of strengths and weaknesses of aquaculture's contribution to regional sustainability

Favourable factors	Unfavourable factors
State involvement and research and teaching structures **V**ery low environmental impact at regional level **H**ighly structured industry **A**doption of quality processes	**L**ow production levels which restrict the sector's recognition as an actor in local development **N**o zones dedicated to aquaculture activity **V**ery few new fish-farmers **N**o structured socio-technical networks **D**ependence on marine products for animal feed

Global assessment in relation to sustainability principles

Finally, it is possible to aggregate all the criteria studied above to obtain a structured global assessment according to the thirteen sustainability principles proposed by the guide (figure 16).

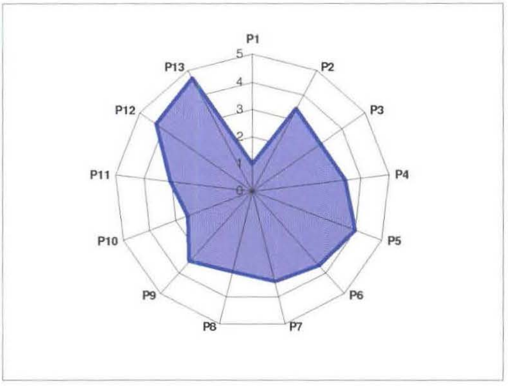
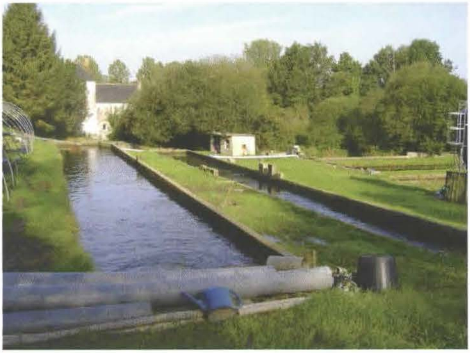


Figure 16. Evaluation of aquaculture sustainability in Brittany according to the principles for sustainable aquaculture

The principles which score the highest for aquaculture sustainability in Brittany are the significant involvement of the State (P13) and associated support activities, in particular, teaching and research (P12). However, this involvement goes hand-in-hand with a significant level of control of the activity, in particular concerning the application of environmental legislation, the incoherence of which prejudices aquaculture development. On the other hand, the principle P1 concerning the contribution to nutritional needs has the lowest score. This situation is 101 due to a low production level combined with the fact that this production is mostly marketed outside of the region, which means that it does not help the social integration of the activity and thereby explains, in part, the relatively low results for principle P10 concerning fish-farming's role in local development. Other principles, particularly enterprise long term future (P7) and social factors (P9) generally have satisfactory scores but it should be noted that the detailed analysis by farm type shows significant type-related disparities in their situations. It should also be noted that the mutualisation process, intended to help cope with crises, is not systematic, particularly in the case of those fish-farmers who remain independent of the professional associations (P8), despite the very dynamic nature of the latter. Likewise, the use of ecolabels and product specifications (P2) is not widespread among such independent fish-farmers. Aquaculture environmental impacts remain moderate (P3,P5) but are increasing with the increase in the quantity produced despite some improvement in the ecological yield (P4).



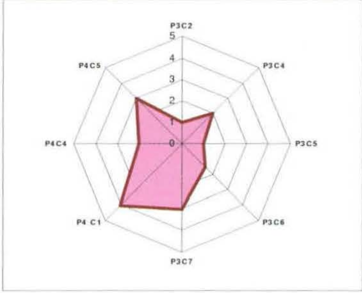
7.3. Sustainability diagnosis of Indonesian cage aquaculture (Cirata Reservoir)

Indonesia is one of the major producing countries in terms of the volume of aquaculture production (third in the world, with over 2.1 million tonnes a year (FAO, 2006)). This production comes mostly from small-scale farms using a variety of rearing techniques (ponds and floating cages mainly) based on an input-intensive farming system. These farms have developed rapidly over the last ten years. The aquaculture system studied here is located on Cirata Reservoir on the island of Java. This is an artificial hydroelectric reservoir where carp and tilapia cage aquaculture has developed, originally to meet the livelihood needs for the re-training of farmers expropriated by the building of the dam in 1988. At present, the rapid increase in the number of cages is leading to environmental overexploitation. The evaluation of the area occupied by floating cages (satellite imagery) shows an occupancy rate of 35%, significantly higher than the estimated carrying capacity of the lake which is estimated between 8 and 12%. Aquaculture activity causes eutrophication of the environment, leading and faces regular crises related, in particular, to epizootic diseases and to anoxic phases due to upwelling. This results periodically in significant population mortality, in particular in shallow waters. KHV (Koi Herpes Virus) epidemics have caused significant carp mortalities and, given the current endemic nature of this disease, some fish-farmers now favour tilapias over carps, as these are not sensitive to the disease although they are somewhat less appreciated by local consumers. Moreover, production is tending to diversify to include other species such as *Colossoma macropomum*, *Pangasianodon hypophthalmus* or *Osteochilus hasseltii*.

Sustainability of aquaculture farms

Diagnoses of the three identified types of farms (table 8) do not show significant differences between types except in the case of three indicators generally related to their size. These three are net operating profit after tax (16.5% of turnover in type 1; 5.1% in type 2 and 12.4% in type 3), output per cubic metre of cage (respectively 4.7; 7.1 and 7.6 tonnes/m^3 for the three types) and contribution to local employment [on average 1.1 in type 1, 2.4 in type 2 and 6.5 in type 3, given that in the absence of a reliable count of farms (and not of cages) it is difficult to assess each type's absolute contribution]. The lower productivity of type 1 farms can be explained by their more extensive practices, principally due to funding constraints. Furthermore, the cages of these farms are mainly located in the zones that are closest to the bank where water quality is poorer and risks are greater. The results shown below cover all farms types regardless of their size, but present each dimension of sustainable development in detail.

Environmental sustainability is assessed according to eight criteria (figure 17) which for the most part achieve low scores.

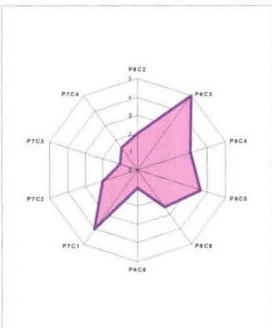


P3C2 Water abstraction
P3C4 Physico-chemical quality of effluents
P3C5 Biological quality of effluents
P3C6 Respect for carrying capacity
P3C7 Existence of management systems
P4C1 Energy control
P4C4 Recycling of by-products (mud and effluents)
P4C5 Level of stock selection

Figure 17. Environmental sustainability of aquaculture farms in Cirata

More than half the criteria score 1 or 2, which places them in the lowest sustainability classes. This concerns particularly the water abstraction (P3C2) understood as the surface occupied by cages, the biological quality of effluents (P3C5), respecting the carrying capacity (P3C6), the use of less-polluting feed (P3C7) and the recycling of by-products (P4C4). Indeed, as highlighted in the introduction, the increase in the number of cages has led to an occupancy rate (35%) of the lake surface higher than its carrying capacity and the use of less polluting feed is not currently being considered by producers. As regards the biological quality of the lake (P3C5), the size of the farmed biomass compared to the environmental capacity leads to a poor self-purification index. The biological oxygen demand over 5 days (BOD5) is about 25 $mg.l^{-1}$ around the cages witch is over four times higher than allowed by the Indonesian norms of 6 $mg.l^{-1}$ (national standard 82, 2001). Suspended particles and nutrient load are also very high. They are six times higher than the amounts in the Citarum River upstream of the lake. Finally, mud deposits, which exceed four meters in the densest areas, are recognised to be a major issue but are difficult to deal with, as technical solutions raise many problems (cleaning out, draining of the reservoir, pumping of the mud, etc.). However a small proportion of this mud is used for food crops on banks that emerge during low water level periods. The evaluation of the physico-chemical quality of effluents (P3C4), with a score of 2, also shows low sustainability, resulting in particular from the widespread, although forbidden, use of antibiotics. Hence, the only criteria belonging to more favourable sustainability classes relate to the existence of management systems (P3C7) and to energy consumption (P4C1) which only concerns motorised transport on the lake -excluding the energy included in the inputs, which is a matter for Life Cycle Assessment (LCA).

The technico-economic dimension, included in a significant number of criteria (10 criteria), also shows relative weakness in terms of sustainability (figure 18).



P6C2 Existence of innovations
P6C3 Relationships with research and extension service
P6C4 Level of economic dependence
P6C5 Control of supply
P6C6 Control of site access
P6C8 Level of sensitivity to pathological risks
P7C1 Value enhancement of products and factors
P7C2 Level of production costs
P7C3 Level of enterprise management
P7C4 Level of financial autonomy

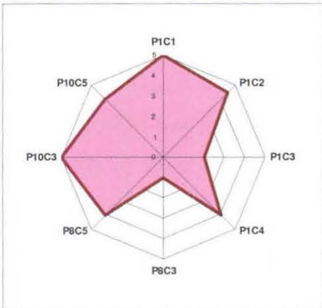
Figure 18. Technico-economic sustainability of aquaculture farms in Cirata

Scores obtained by most criteria correspond to lower-than-average sustainability classes (class 3). Only the value enhancement of products and factors (score of 4), the control of supply (score of 3.5) and the relationships with technical advisers and research (outstanding score of 5 due to monthly frequency) belong to classes of good or very good sustainability. Although production is not exported, the value obtained from products and factors benefits from the short production cycle which is very favourable with 3.3 cycles a year. Fry and fingerling supply does not seem to be a problem from the quantitative point of view. From the qualitative point of view, although the survival rate of larvae and juveniles is satisfactory, fish-farmers feel that there is a need for health control by site and by hatchery. As regards feed, the constraint is not availability but cost, as this represents on average 77% of production cost.

Leaving aside these rather positive aspects, other criteria are indicative of situations which are far less favourable. The existence of innovations (P6C2), covered by 6 indicators, is penalised by weak professional organisation and collaborative networks between fish-farmers as well as by the lack of appropriate credits. The level of economic dependence (P6C4) of aquaculture farms, despite the advantage of low salary costs, is weakened by an input/output ratio of 86% on average. This situation may be explained by the relative importance of production costs (criterion P7C2 with a score of 1) mainly due to the cost of feed and to a relatively high fish mortality rate (10-15% for each production cycle). Controlling access to the production site and improvements of environmental safety (P6C6), rarely go beyond the stages of brainstorming or pilot. It should be noted that the differences in productivity and in risks linked to occupancy density and lake depth lead to very significant competition between producers for the best sites, i.e. further offshore. The least favourable criteria (scores of 1 or 1.5) concern the level of sensitivity to pathological risks (P6C8) as there is no systematic surveillance system for aquaculture pathologies, the level of enterprise management (P7C3) with low utilisation of expenditure and income record-keeping, and the level of financial autonomy (P7C4) shown by net results and the self-financing capacity.

Unlike the previous two dimensions, the eight criteria which reflect social sustainability indicate a situation which is significantly more favourable (figure 19). Only two criteria still score poorly, these being the level of training with only 19% of farmers having benefited from specialised training in aquaculture, and the nutritional level as low attention is paid to quality approach. At nutritional quality level, there is again the constraint linked to the absence of implementation of a monitoring plan relating to the control of residue and contaminants, whilst some measurements of heavy metals show a very low level of contamination (traces). On the other hand, nearly all the other criteria belong to classes 4 and 5 of sustainability.

Finally, the institutional dimension assesses governance conditions using 9 criteria which, like the social aspects, indicate a rather positive evaluation for sustainability. As shown in figure 20, the only criterion with an insufficient score (<3) concerns the still restricted access to the aquaculture information system (database, GIS, technical manuals,...). It should also be noted that, among indicators, the one relating to the absence of corruption with a score of 1 can be significantly improved.



P1C1 Fish availability
P1C2 Accessibility to the production for all
P1C3 Nutritional level
P1C4 Presence of xenobiotics
P8C3 Level of training
P8C5 Access to information
P10C3 Level of contribution to local employment
P10C5 Level of contribution to local economy

Figure 19. Social sustainability of aquaculture farms in Cirata

Some factors indicate contrasting situations according to the dimension. Hence, multi-activity (considered in the level of contribution to local economy, P10C5, figure 19) which is positive for the economic security of the farmer, is at the same time restrictive for the professionalisation and recognition of the sector, and consequently for the organisation of governance mechanisms. The very favourable score for the capacity of governance mechanisms is based on a single indicator which is the existence of a dialogue system between the State and the industry. This is only a very partial evaluation which does not really do justice to the multi-dimensional nature of governance conditions. This score should therefore be treated with caution. The scarcity of available information concerning criteria related to the role of the State and public actors in implementing sustainable development must be stressed (P13).

P11C3 Participation level
P12C1 Importance of research in aquaculture
P12C3 Level of research-industry interaction
P12C4 Aquaculture information systems
P12C5 Access to scientific and administrative data
P13C1 Level of national recognition of sustainable development
P13C2 Level of State involvement in sustainable development
P13C3 Level of State commitment towards the industry
P13C4 Capacity of governance systems

Figure 20. Institutional sustainability of aquaculture farms in Cirata

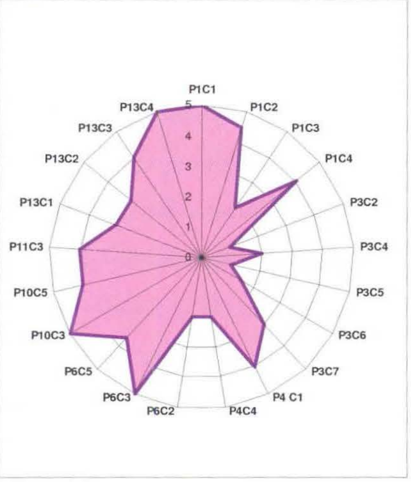
To summarise, an overall assessment of favourable and unfavourable factors for farm sustainability can be established (table 12).

Dimensions	Favourable factors	Unfavourable factors
Environmental	**L**ow energy level (leaving aside inputs)	**E**xcessive number of cages and lack of effective regulation in order to respect the carrying capacity **P**oor biological quality of effluents **N**o control on the use of veterinary or toxic substances
Technico-economic	**S**hort production cycle **F**requency of contacts with research and extension services	**H**igh mortality and no epidemiological monitoring **L**ow self-financing capacity **I**nnovation constraint and lack of collective and financial incentives **L**ack of good aquaculture practices **I**nadequate management of farms
Social	**V**ery significant national and local production **C**ompetitive prices (accessibility) **J**ob creation	**L**ittle interest in quality **N**o plan for controlling xenobiotics **P**oor level of technical training for fish-farmers
Governance	**S**ignificant involvement of the State in aquaculture support	**N**eed to modernise aquaculture information systems **N**eed to increase awareness of sustainable development

Table 12. Summary of strengths and weaknesses of farm sustainability in Cirata

The contribution of aquaculture to the sustainability of the area

Analysing the interactions between aquaculture activity and the area in which it operates makes it possible to evaluate favourable and unfavourable factors in the contribution that aquaculture makes to the sustainability of this area. Twenty one criteria were selected, of which seven only are specific to this scale, the others being common to the diagnosis centred on aquaculture sustainability. However, in this case, due to the change in the point of view, the scores of the latter criteria sometimes lead to a different evaluation. Figure 21 shows the results for the sustainability of the Cirata area.



P1C1 Fish availability – P1C2 Level of accessibility – P1C3 Nutritional level – P1C4 Presence of xenobiotics – P3C2 Water abstraction – P3C4 Physico-chemical quality of effluents – P3C5 Biological quality of effluents – P3C6 Respect for carrying capacity – P3C7 Existence of a management system – P4C1 Energy control – P4C4 Recycling of by-products, mud and effluents – P6C2 Existence of innovations – P6C3 Nature of relationships with research and extension service – P6C5 Control of supply – P10C3 Contribution to local employment – P10C5 Contribution to local economy – P11C3 Participation level – P13C1 Level of national recognition of sustainable development – P13C2 State involvement in sustainable development - P13C3 Level of State commitment towards the industry – P13C4 Capacity of governance systems.

Figure 21. Diagnosis of the contribution of aquaculture to the sustainability of the Cirata area

Despite quite significant management systems (score of 3), interactions between aquaculture and the area's environmental resources indicate a rather negative impact as regards conservation goals and respect for environmental capacity and quality. At a nutritional level, this low score can be explained by the still embryonic stage of the implementation of a focus on quality (P1C3) whilst availability compared to nutritional needs is very favourable (P1C1 and P1C2). With an annual production of 77,000 tonnes, Cirata meets more than 72% of the requirements of the province's population for aquaculture products from inland aquaculture, in particular through self consumption – a widespread habit – and because the price is relatively favourable compared to the price of chicken (36%). The activity is a driving force for the area's development in socio-economic terms through its positive impact on employment (P10C3) and on the local economy (P10C5). Indeed, despite the absence of any assessment due to the lack of professional organisations, surveys have shown the significant direct number of jobs generated by the activity (4.5 by aquaculture farm, i.e. about 13,000 in total). Finally, from an institutional point of view, noteworthy results can be observed in governance mechanisms (P13C4, even though we have seen that the way they were apprehended could be perfected) and the level of commitment of the state to the sector (P13C3) is highly satisfactory. All in all, aquaculture seems to make quite a positive economic, social and institutional contribution to the Cirata region, although it also has some rather negative environmental effects.

Global assessment in relation to sustainability principles

The mean value over all the criteria is 3.03, which is slightly above the average score of 3. The assessment by dimension shows that the environmental (average 2.2) and technico-economic (average 2.6) aspects pose a problem whilst social and governance aspects with averages respectively of 3.6 and 3.7 score better on the sustainability scale. However, these global evaluations do not provide a sufficiently detailed diagnosis to generate recommendations in terms of decision-making, either for professionals, from a farmer's viewpoint, or for public institutions responsible for the supervision of the sector, from a more general viewpoint. A synthesis of the criteria, following the thirteen principles applied to aquaculture sustainability (figure 22), enables a global diagnosis to be made according to the major challenges facing aquaculture which can be integrated into the new reference framework for sustainable development.

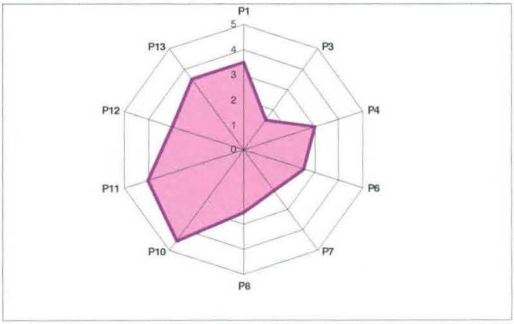


Figure 22. Synthesis of the aquaculture sustainability assessment in Cirata according to the sustainability principles for aquaculture

This approach enables the identification of four principles for which the aquaculture system under study scores high or very high (scores higher than 3). Globally, it is in terms of area development (P10) that Cirata aquaculture scores best, in particular because of its significant contribution to local employment. The diagnosis is also positive concerning the contribution to meeting nutritional needs (P1) (social aspect), participation and governance (P11) and the role of the State and public actors in implementing sustainable development (P13), which relates to the governance dimension. The other social components, relating to the organisation and the identity of the sector (P8) and to social investment within farms, score slightly less than average (2.5) for principle P8, or were not even selected as regards social investment which indicates serious social failing at the farm level.

Principle P2 relating to the quality approach was not included in analyses as this approach which can be measured via labelling or certification does not exist in Indonesia at the moment. However, as we have seen in the detailed analysis of farm sustainability, the low level of interest in a quality approach is the consequence of the absence of exports although professionals who seek to diversify their markets, in particular at international level, are starting to take it into consideration.

Concerning the environmental dimension, the low score of the principle relating to natural resources and adaptation to the environment carrying capacity (P3) reflects the lack of control of lake occupancy and practices which are harmful for the quality of effluents. The issue of biodiversity and animal well-being (P5) was not selected by actors, who are only just, as in the case of quality, becoming aware of the importance of this issue for good practice and animal well-being. Finally, at an economic level, the low score (2) of principle P7 relating to the long term future of farms (significant costs, poor financial autonomy and management...) is very worrying, particularly in the local context of repetitive environmental crises which can precipitate bankruptcies and restructuring in favour of large business concerns and sector concentration at the expense of the social diversity of different aquaculture types.

Conclusion

Rather than reiterate the particular properties of the guide, which are developed in chapters 1 and 2, this conclusion aims to clarify why it is of interest and position it in relation to recent theoretical developments in the field of sustainable development evaluation. These developments recommend methodological approaches similar to the one that we propose (Lazzeri and Moustier, 2008), in particular the joint approach to building and nesting Principles, Criteria and Indicators which underpin this guide. With its modular nature, its applied examples and the tools developed in the appendix, this guide to a joint approach to building principles, criteria and indicators for sustainable development in aquaculture is a pragmatic tool. It can support sustainability evaluation and the implementation of sustainable development policies in aquaculture. It helps to clarify implementation conditions for joint construction approaches. As argued by Baslé (2000) with respect to public policies, "to evaluate is to make sense together" and it is the collective and context-based nature of the approach which characterises the spirit of this guide.

The joint approach meets the new requirements relating to the implementation of public action in a context where governance and participation issues are strategic. Using the co-construction process as the entry point shows the authors' determination to take into account critical progress made in recent years concerning the effective use of indicator systems for sustainable development. It has become obvious that constraints do not relate simply to technical factors or lack of information, which were often just excuses. As highlighted by Olsen (2000) with respect to coastal sustainable development, the limiting factor is not lack of knowledge but the absence of a strategy to ensure that governance is inclusive, participatory and responds to the values and concerns of the people on their own turf. Retrospective studies on sustainable development indicators highlight the risks and conditions for these indicators to be genuinely adopted and used by actors. It is particularly important to clarify as far as possible the choices of value systems conveyed by these indicators. No choice of variable or weighting is neutral and they should be discussed. Hence, as argued by Perret (2002) "the task of choosing and prioritising aspects of social reality must be carried out collectively and within an appropriate institutional framework". These findings justify the importance given to governance in the suggested approach, both in the implementation method (governance of the indicator construction system promoting the participatory dimension) and in the dimensions of sustainable development where governance is integrated as the fourth dimension of sustainable development (governance of aquaculture systems and of the host regions).

After an exploratory phase where efforts were focused on a fruitless search for exhaustivity or increasing accuracy, the new challenges relating to the evaluation of public policies, the transparency of negotiations, the sharing of and access to information tend to stress indicator comprehensibility, legitimacy and simplicity. In such a context, an increasing number of researchers and experts recommend a joint building process which would lead to an indicator system representative of a certain consensus reached by the relevant actors. To that end, over and above indicators, it is part of a process to create a regional and decentralised public interest (Lascoumes and Le Bourhis, 1998). The "principles, criteria, indicators" methodological framework recommended by the guide makes it possible to link the monitoring of sustainability, defined as qualitative classes, to issues identified and priorities selected according to the context. With this type of monitoring by sustainability classes, field measurements or statistical data can be combined with expert opinion to include certain qualitative factors that had been neglected until now through lack of information. The objective of the approach is to favour a balance between dimensions over the accuracy of measurement, in order to avoid focusing on environmental aspects or on better known variables.

The proposed guide was trialed in six highly contrasting areas, as shown by the two examples presented in chapter 7. Over and above the diagnoses established through the joint building approach, its implementation always served to strengthen the relationships between researchers, professional and institutional actors. Hence, in each system, aquaculture stakeholders were very often particularly aware of the opportunity they had to express their opinions and viewpoints. In the end, the researchers learnt as much about the systems they were studying as the actors did about the evaluation of, and the issues concerning, sustainable development. Even though selected principles, criteria and indicators varied according to the region, nonetheless many of them were common to several aquaculture systems. It should be stressed that differences of opinion usually relate to the status of surveyed actors (in particular between producers and institutional actors) and to enterprise size rather than to types of aquaculture systems or to countries. This means that when this guide is implemented in other aquaculture systems, those initiating the approach should define a very open pioneering group and ensure broad-based actor participation. It is these conditions of openness and dialogue that maximise the relevance of the results produced by this generic approach in terms of the balance between dimensions and the closest of general archetypes hence facilitating inter-scale and inter-regional comparisons.

In many cases, working groups have not only brought actors closer together but have also generated requests for institutionalisation of these dialogue mechanisms. Hence, the guide is only the first loop of a process which can be continued, thereby giving rise to several successive loops. The indicator system produced is a step towards the establishment of an observatory which will be sustainable if it has the capacity to adapt continually to developments whilst benefiting from the collective learning of actors who are mobilised and involved in this observatory. Hence, the results of the approach concern the cognitive viewpoint through the knowledge it generates on sustainability as well as the organisational and institutional viewpoints through its participatory nature. Identifying these results requires a reflexive process and a regular evaluation of the system underpinning the continuous improvement strategy recommended by the reference framework for territorial (regional) sustainable development projects set up in France by the Ministry for Ecology, Development and Sustainability (Lazzeri and Moustier, 2008).

Finally, looking beyond aquaculture, the authors sought to be pragmatic and educational throughout this guide, enabling the latter to be also a useful reference for regional approaches to building sustainable development indicators relating to other activities or to integrated approaches at the scale of a region.

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APPENDICES

- 1- Reference framework for criteria and indicators
- 2- Examples of survey and interview questionnaires
- 3- Model of descriptive sheet for indicators
- 4- Definition of aquaculture systems

APPENDIX 1
Reference framework for criteria and indicators

Code	Heading	Sectoral indicators	Regional indicators
P1C1	**Importance of fish availability**	**Annual production**	
P1C2	**Level of accessibility**	**Quantity of fish produced for local markets and self-consumption**	
		Fish price compared with the minimum wage	
P1C3	**Level of nutritional contribution**	**Commitment to and type of quality-based approach adopted by the enterprises (existence of product specifications, quality labels ...)**	Percentage of the production covered by a quality-based approach (by type of approach)
P1C4	Presence of xenobiotics	Preservative and heavy metal concentration ratios	Number of control agencies and effectiveness of the control
P1C5	Importance of processing	Percentage of innovative products proposed each year	
		Percentage of processed products	

Principle no. 1 (P1) Contribute to fulfilling the nutritional needs of societies

Code	Heading	Sectoral indicators	Regional indicators
P2C1	**Existence of a quality-based approach**	Number of labels or certification schemes	
		Existence of quality charters	
		Percentage of labelled production	
		Percentage of innovative products proposed each year	
P2C2	Existence of traceability	Existence of a traceability approach	
P2C3	Level of value enhancement	Production volumes exported	
		Percentage of the production destined for export	
		Price differential with respect to quality	
P2C4	Existence of segmentation	Number of product ranges proposed (top quality and everyday consumption)	
P2C5	Existence of appropriate processing capacity	Ratio of production to processing capacity	

Principle no. 2 (P2) Develop approaches which promote quality

Code	Heading	Sectoral indicators	Regional indicators
P3C1	Importance of harvesting from fish stocks	Conversion ratio (production sold / nutritional contribution)	Level of alevin stocks and fodder species in the natural environment
		Percentage in weight of inputs from fishing in the feed (unprocessed or processed)	
P3C2	Importance of water abstraction	Volume (in m^3) of water abstracted per kg of product	Percentage of reserved flows
			Ratio of kg of fish to incoming flow
P3C3	Importance of spatial occupancy	Ratio of kg of produced fish per hectare (direct and impacted)	Percentage of water surface covered
			Percentage of spatial occupancy compared to the environmental carrying capacity
			Frequency of anoxic episodes
P3C4	**Level of physico-chemical quality of effluents**	**Use of antibiotics and veterinary products per kg of fish produced**	Ratio of weight of active chemicals per kg of fish produced
			Percentage of enterprises using sodium cyanide and prohibited products dangerous for the environment
P3C5	**Level of biological quality of effluents**	**Particle, nutrient and suspended particle matter load in discharges**	
		Oxygen level in effluents	
		Percentage of a less polluting range of products in the feed	
		Presence of a system to improve water quality (filter, stirrer...)	
P3C6	**Respect for carrying capacity**		**Self-purification index (environmental resilience capacity)**
			Quantities produced compared to environmental capacity
			Existence of public incentives to respect carrying capacity
			Dilution index
P3C7	Existence of management systems		Number of resource management committees

Principle no. 3 (P3) Ensure respect for natural resources and adaptation to the environmental capacity

Code	Heading	Sectoral indicators	Regional indicators
P4C1	**Energy control**	**Energetic yield (KW per kg of fish per energy source)**	
P4C2	Level of productivity compared to resources	Ratio of Kg of fish produced per m^3 of water	
		Ecological footprint index of the enterprise	
P4C3	Level of life cycle assessment (LCA) of the enterprise		Contribution to climate change and acidification (LCA indicators)
P4C4	Existence of by-product recycling	Field area fertilised for aquaculture	Purification rate related to aquaculture activity
P4C5	**Existence and selection level of strains**	**Feed conversion ratio**	
		Ratio of Kg of produced fish per hectare	
		Protein yield	
P4C6	Polyculture level	Number of species in the same farming structure (polyculture)	Value enhancement level of the trophic chain (polyculture, integrated farming...)

Principle no. 4 (P4) Improve the ecological yield of the activity

Principle no. 5 (P5) Protect biodiversity and respect animal well-being

Code	Heading	Sectoral indicators	Regional indicators
P5C1	Importance of genetic pollution		Abundance index
			Escapement rate (number of escapees per produced fish)
			Introgression rate
P5C2	Nature of farmed species		Farming sentinel species
			Number of species introduced for aquaculture purposes
			Number of non-native species of aquaculture origin established in the environment
P5C3	Capacity to protect habitats		Biodiversity indicator (benthos and pelagos)
			Specific diversity index of the farming site biotopes (quantity of wild fish and crustaceans sold on fish markets)
			Implementation of a mangrove protection policy
			Percentage of area evolution into a sensitive biotope (mangrove, wetlands...)
P5C4	**Nature of farming and slaughtering practices with respect to animals**	Ratio of fish sold (excluding substandard fish) to fish farmed	
		Percentage of well-formed and healthy-looking fish	
		Number of declared pathologies	
		Survival rate of well-formed fish with no lesions	

Code	Heading	Sectoral indicators	Regional indicators
P6C1	Level of diversification	Number of species produced	Percentage of enterprises engaged in pluriactivity
		Number of products	
		Number of goods and services proposed	
		Access to the services of a hatchery	
		Existence of pluriactivity within the farm	
		Number of different markets available	
P6C2	**Existence of innovations**	Number of new species	Existence and type of credits in support of innovation
		Tonnage by new species	Number of enterprises benefiting from credit
		Mutualisation of factors of production (e.g. genitors, strains...)	
		Pace of introduction of new technologies (2, 5, 10, 20 years)	
		Tonnage: new technologies ratio	
		Number of co-operatives / producer associations	
P6C3	**Nature of the relationships with research and extension service**	Number of participatory trials	Fish-farmers' participation rate in seminars
		Links with a socio-technical network	**Frequency of scientific seminars for dissemination**
P6C4	Level of economic dependence	Percentage of fish meal in the feed	
		Percentage of fish oil in the feed	
		Level of salary costs compared to turnover	
		Production expenditure (intermediate inputs / total expenditure)	
		Ratio of gross expenditure to gross income	
P6C5	**Supply control**	**Availability of alevins and average price**	Degree of value enhancement of local products (alevins, feed, agro-industrial by-products)
		Quantity marketed by hatcheries (by species and by territory)	Degree of value enhancement of local products (alevins, feed, agro-industrial by-products)
		Survival rate of alevins and larvae	
		Satisfaction index with respect to alevin supply	
		Number of potential feed suppliers for the enterprise	
		Price per kg of commercial feed	
		Existence and effectiveness of health controls by year and by hatchery	

P6C6	**Control of site access**	Nature and level of investments required to improve the environmental safety of farms (dredging channels, moving cages, septic tanks, waste disposal)	Existence of master plans
		Purchase price or rental per hectare	
		Percentage of authorisations compared to applications	
		Duration of current exploitation authorisations	
P6C7	Level of awareness of natural hazards	Number of production incidents leading to the loss of the stock (in tonnes, in percentage of production, in value)	Number of controls each year of environmental quality
		Number of insured enterprises (public systems: for natural disasters and private systems: mutualisation)	Existence of a warning system
			Number of infractions
P6C8	Level of sensitivity to pathological risks	Importance of production losses due to pathologies (frequency and size)	Number of controls each year of environmental quality
			Existence of a warning system
P6C9	Insurance level	Percentage of compensation compared to losses	Average timescale for compensation in case of incident

Principle no. 6 (P6) Increase the capacity to cope with uncertainty and crises

(Two tables)

Code	Heading	Sectoral indicators	Regional indicators
P7C1	**Level of value enhancement for products and factors**	**Duration of production cycle**	
P7C2	**Level of production costs**	**Average mortality rate of the stock**	
P7C3	Level of management	Percentage of energy costs compared to turnover	
		Expenditure and income record-keeping	
		Proportion of production destined to be sold compared to self-consumption	
P7C4	**Level of financial autonomy**	Debt / capital ratio	
		Level of debt	
		Net operating profit (compared to turnover)	
P7C5	Access to funding	Capitalist level (labour expenditure / total expenditure)	
P7C6	Level of vertical integration	Integration rate of upstream and downstream functions (five functions from hatchery to marketing)	
		Supply and sales by contract or by market	
P7C7	Capacity to pass on enterprises	Presence or absence of a family buyer	Number of fish-farmers aged over 60
		Enterprise profitability (gross operating surplus / fixed capital)	Existence of a mechanism to help start-ups
			Rate at which companies are passed on

Principle no. 7 (P7) Strengthen enterprise long term future

Code	Heading	Sectoral indicators	Regional indicators
P8C1	Average salary levels	Minimum wage of employees compared to national minimum wage	
P8C2	Access to the system of social protection	Existence of a professional status	
		Payment of social contributions	
		Existence of trade unions for employees and fish-farmers	
		Existence of professional organisations and consular chambers	
P8C3	**Training level**	Average level of training	
		Percentage of fish-farmers with specialised aquaculture training	
P8C4	Importance of networks	Fish-farmers' participation rate at professional seminars	Genuine existence of sustainability approaches
		Number and nature of associations	Percentage of fish-farmers aware of sustainable development issues and tools
P8C5	Access to information	Existence and number of professional publications	
P8C6	Image of aquaculture	Existence of ecolabels and product specifications	
		Existence of communication mechanisms for the sector	
		Number of open days	
P8C7	Existence and importance of trade unions	Number of sectoral representatives in regulatory mechanisms	
P8C8	Capacity to take part in decision-making		Number of links between the activity and the networks: institutional, denominational and informal

Principle no. 8 (P8) Strengthen the organisation and identity of the sector

Code	Heading	Sectoral indicators	Regional indicators
P9C1	Level of working conditions	Number of enterprises having committed to CSR (Corporate Social Responsibility)	
		Number of monthly hours actually worked by aquaculture workers	
		Existence of effective standards concerning aquaculture workers' housing	
		Frequency of occupational accidents	
		Frequency of conflicts between employer and employees	
P9C2	Level of protection and of trade union membership of the staff	Homogeneity of work contracts	
		Percentage of trade union members among workers	
P9C3	Importance of women's access to the industry	Percentage of women fish-farmers (enterprise directors and managers) and in the value chain, especially professional organisations	Number of measures facilitating access for excluded people
		Percentage of women owning the means of production	
P9C4	Existence of equal pay for men and women	Salary gap between men and women	
P9C5	Access to information	Number of interprofessional organisations	
P9C6	Level of isolation and living conditions	Taking into account farms' isolation	

Principle no. 9 (P9) Strengthen companies' social investment

Code	Heading	Sectoral indicators	Regional indicators
P10C1	Importance of development initiatives		Number and area of improved and developed zones
			Length (in linear meters) of hedge plantations
			Length of maintained raceways and watercourses
			Existence of landscape charters
P10C2	Importance of the wealth-building role		Emblematic nature of farmed species
			Age and historical role of the activity
			Contribution to the traditional landscape of the area
P10C3	**Level of contribution to local employment and to poverty reduction**	**Number of jobs**	Percentage of aquaculture-related productive jobs compared to local jobs
			Percentage of aquaculture jobs compared to productive jobs
		Breakdown between permanent and temporary jobs	Number of permanent local aquaculture jobs (jobs directly related to the sector and jobs created by the value chain)
P10C4	Level of contribution to public budgets		Percentage of corporate tax and land tax compared to the budgets of local authorities
P10C5	**Level of contribution to local economy**	Percentage of pluriactive enterprises	**Type of relations with the tourist sector (positive externalities: direct sale, housing, recreational activities, "open days" or negative externalities: conflicts...)**
			Percentage of tonnage sold for stock enhancement, recreational fishing, direct restaurant trade
P10C6	Importance of the sector's environmental functions	Number of times aquaculture facilities have been recycled	Percentage of enterprises integrating (upstream/downstream) activities
		Existence of agricultural and aquaculture joint-production (e.g. rizi-pisciculture)	Recycling rate at value chain level (e.g. value enhancement of trimmings)
		Number of animal and vegetal species produced on the farm	
P10C7	Capacity as environmental indicator		Existence of aqua-environmental measures
			Existence of environmental monitoring
			Number of environmental crises reported in five years
P10C8	Level of social recognition	Proportion of production that is donated	Existence of advisory centre for workers in difficulty or of schools on the farm sites
		Links with a socio-professional network	
		Frequency of participation in local organisations and political life	
P10C9	Importance of the sector's local representation		Presence of aquaculture industry representatives in local assemblies

Principle no. 10 (P10) Strengthen the role of aquaculture in regional development

Code	Heading	Sectoral indicators	Regional indicators
P11C1	Level of comprehensibility of the industry		Number of training seminars
			Percentage of fish-farmers and technicians who know the regulations
			Number of technical sheets for fish-farmers and institutional actors
P11C2	Existence of control systems		Number of agents involved in control
			Percentage of fish-farmers in breach of the law
			Percentage of reported infringements
			Percentage of fish-farmers using prohibited substances
			Number of conflicts with the administration
P11C3	**Level of participation**	Number of participants at consultative meetings	**Number of regional consultative meetings**
			Number of new measures developed jointly
			Number of fish-farmers taking part in consultative bodies
			Number of conflicts between producers and environmental associations
P11C4	Level of decentralisation of decision-making		Number of conflicts solved at local level
			Number of conflicts due to contradictions between traditional and constitutional legislation
			Local presence of management institutions
P11C5	Level of management and regional planning	Number of authorisations granted compared to the number of requests	Number of new sites created
			Existence of an occupancy plan for aquaculture land

Principle no. 11 (P11) Promote participation and governance

Code	Heading	Sectoral indicators	Regional indicators
P12C1	Importance of research in aquaculture	Existence of research funds	
		Existence of laboratories, institutes or research bodies specialised in aquaculture research (natural and social sciences)	
P12C2	Importance of training in aquaculture	Existence of organisations for and support to aquaculture training	
P12C3	**Level of interaction between research and industry**	**Number of partnership contracts**	
		Existence of a joint evaluation of results	
P12C4	**Access to aquaculture information systems**	**Existence of an information system (Geographic Information System, databases, technical sheets ...)**	
P12C5	**Access to scientific and administrative data**	**Existence of a dissemination service**	

Principle no. 12 (P12) Strengthen research and sector-related information

Code	Heading	Sectoral indicators	Regional indicators
P13C1	**Level of national recognition of sustainable development**	**Existence of a sustainable development strategy (national and/or regional)**	
		Existence of rules and regulations in favour of sustainable development	
		Existence of a national and/or regional will to develop aquaculture	
		Weight of underground economy	
P13C2	**Level of implication of the State in sustainable development**	**Absence of corruption**	Number of favourable decisions in response to aquaculture requests to occupy public maritime space
		Amount of State financial aid compared to other sectors	Number of concessions granted for aquaculture
		Effective enforcement of governmental decisions	Existence of competent State services (ministry, institute, etc.)
		Existence of a public support plan for aquaculture	
P13C3	**Level of commitment of the State towards the industry**	**Existence of research and training funds**	
		Existence of public services at local level	
		Aquaculture-related decisions based on reliable data	
		Quality of the legal system (legal actions are possible and judgments are enacted)	
		Existence of an appropriate lending system	
P13C4	Capacity of governance systems	Consultation mechanisms between State and industry at national, regional and local levels	
P13C5	Familiarity with and local support to sustainable development (local agenda 21s)	Participation in the construction of the local agenda 21 or other similar system	Existence of an agenda 21 or other similar system at local level

Principle no. 13 (P13) Strengthen the role of the State and of public actors in implementing sustainable development

APPENDIX 2
Examples of survey and interview questionnaires

1- Example of a survey guide for aquaculture enterprises

PREAMBLE

The survey of farms occurs in stage 4 of the joint approach to building principles, criteria and indicators (PCI). The aim is to collect data which define aquaculture systems in technical, economic and relational terms, and identify types of farms, strengths and constraints and types of regulation together with complementary issues identified during the surveys concerning the representations. In particular, they enable PCI to be set into context.

The questionnaire can be more or less comprehensive and must be adapted using prior knowledge of the system(s), i.e. from existing field knowledge and available information. Box 11 makes some recommendations for survey practice.

Depending on local human resource availability, it is recommended that aquaculture managers with a sound knowledge of the area and aquaculture stakeholders carry out the surveys. All the surveys should be undertaken by the same enumerators. Failing that, the surveys can be carried out by non-aquaculture enumerators (students, agricultural advisers, researchers, ...) after they have been trained appropriately.

The enterprise manager is the priority for the survey. However, in some cases (depending on the management system and the enterprise status), it can be carried out with the enterprise manager's wife, a member of the family who knows the enterprise well or else with a, or the, foreman. However, where some questions are concerned (for example those relating to the enterprise's future and projects), the interviewee must be able to answer as if he/she were the enterprise manager or when this is not possible, these questions should be kept for a shorter interview with the enterprise manager.

A certain number of key variables are listed in this survey guide as these can be part of the questionnaire according to the information required to define aquaculture systems. The variables are organised around the six topics which provide the headings for the survey sections:
- general information about the interviewee
- history and social environment of the enterprise
- production system (unit size, species etc.)
- marketing aspects (selling methods)
- the enterprise's future and projects (passing on of the enterprise, growth, etc.)
- regulatory system (constraints, conflicts, etc.)

The variables in bold are those considered to be the most structuring when constructing typologies and setting the PCI list into context. For some variables, details have been added in brackets, in particular in italics, in order to give some examples of methods that might be adapted according to the area.

THE SURVEY GUIDE

I. General information

Name, first name, status (owner, head of family, enterprise manager, technical manager, …)

II. History, family and environment

◙ Origin and family
- Age of the farmer, Year they started the business, Number of years spent in the same place.
- Existence and type of aid for installation, Mode of access to enterprise (inherited, purchase, creation…), Work in the family enterprise or not before setting up own business.
- Number of individuals in the family

◙ Type and level of external relationships
- Percentage of time dedicated to aquaculture, Number of activities outside aquaculture, Existence of external income (enterprise manager, wife, other family member), Percentage of family income derived from aquaculture, Type of land ownership (owner belongs to an industrial group, independent owner, owner integrated upstream and/or downstream, farmer or sharecropper…)
- Existence of family or other network in the industry, existence of collaboration with other fish-farmers.
- Number of professional associations and co-operatives, Number of non-professional associations (for example ecologists' association, river basin management agency, excluding religious or political associations) to which the farmer belongs, current local importance of fish-farming
- Existence of general or technical information exchanges with aquaculture and aquaculture-related stakeholders, Contact in case of problems (professional organisation/association, administrative services, family/chiefdom, scientific research services), Existence, frequency and type of relationship with research, Technical advisory services (administrative service, researchers, professional organisation/association, family, other professionals, private adviser).

◙ Economic management methods
- Existence of accounts, Existence of a connection between enterprise income and family (is it a regular income or does it depend on results? in case of difficulties, which comes first? family income or investments?)
- Total borrowings for installation, existence and value of savings, existence and value of investments in the past five years.
- Total annual turnover, feed expenditure, fry expenditure, workforce (temporary and permanent) expenditure.
- Existence and amount of subsidies

III. Production system

◙ Production sites and unit size
- Number of sites, Total production capacities in m3 for cages/basins and in hectares for lagoons.

- Type of facilities for effluent treatment
- Ease of access to site(s)
- Total annual production in tonnes, total annual quantity of feed (or fertiliser) used

◘ Specialisation and production site
- Type of farming structure (sea cages, freshwater cages, basins with recycling, basin or lagoon without recycling …), Integration into other farming systems (pigs, chickens etc.), Farming density, number of cycles per year, type of farming (fattening, hatchery and fattening, nursery and fattening)
- Number of aquaculture species farmed, Type of farming when several species (monoculture, polyculture etc.)

◘ Structure and level of work involved
- Level of general training, level of workers' technical training
- Contribution and frequency of work by family members, Total number of family members working in the farm
- Total number of persons outside the family working in the farm (maximum and minimum number of persons), Number of annual employment equivalent, Use of sub-contractors
- Number of salaried persons

◘ Know-how, training and information
Origin of the techniques used (experience, other fish-farmers, extension agents ...). Modification and adaptation of the techniques, Pace of innovation.

◘ Product diversification
Range of products. Change of products (with specialisation or diversification in mind).

IV. Marketing

- Number and breakdown of selling methods by product (fish market, wholesaler, restaurants, direct sales, self-consumption, fish-restocking, processing, …), Existence and proportion of donations and of self-consumption
- Change in selling methods.

V. Individual and collective projects

- Existence of self-financing capacity, Existence of a succession for the future,
- Existence of recent investments, Changes in infrastructure, Change in planned technical system, Change in planned species (diversification, specialisation), Change in planned sales circuits,
- Existence of collective technical or commercial projects, Participation in regional projects
- Desire to intensify or to reduce the intensification of the factor of production (labour, capital, land, water, input …)
- Existence of measures or risks calling into question the long term future of the enterprise.

VI. Regulatory system

◘ Regulatory level and method
- Existence of a connection with the administration, Existence of particular fees to be paid in

order to undertake an activity.
- Existence of local traditional representatives, Existence of agreements between producers, Existence and frequency of local meetings of the industry
- Existence of local regulations respected or to be respected, List of legislation concerning the activity (water, land, labour, ...)
- Level of formal and informal constraints on water, land, production rights, feed, discharges, sales price …, Comparison of the level of constraints with that of other activities (agriculture, artisanal fisheries, shellfish culture, forest ...)
- Existence of a control system
- Conditions of, and constraints on, entry into the industry

◙ Conflicts
Types (internal or external to the industry), frequency (occasional, frequent, permanent) and nature (about the use of water, discharges and pollution, land or marine spatial access, ...) of conflicts, Methods put into place locally to regulate conflicts (legislation, informal regulation etc.).

◙ Exploitation constraints and conditions
- Activity–related satisfaction or dissatisfaction factors (unpleasantness, risk, safe economic outcome, annual distribution of working time etc.)
- Main constraints (water (quantity, quality), workforce, administrative rules, other competing economic activities, land, production rights, know-how / technical sophistication, fry availability, fry quality, markets, funding…)

EVAD

2. Example of survey questionnaire. Interview about sustainable development representations

PREAMBLE

Overview of the nature and the role of representations
Representations are social constructions which act as framework or reference for the action. Any suggestion of change must fit within this framework or reference in order to have a chance to succeed, and this is the case for sustainable development. For this reason, it is important to know fish-farmers' representations so that the probability of sustainable development being adopted by fish-farmers and other stakeholders as the new reference framework can be assessed.

Representation analysis has a dual objective:
• descriptive: express the representation actors have of sustainable development and of the way it should be put into place
• comprehensive: analyse the situation produced by the implementation of sustainable development through the viewpoints and the actions it generates in the different actors.

Objective of the interview:
• define collective representations
• identify local issues related to aquaculture
• analyse the coherence between the sustainable development model and actors' situation
• analyse intra- and inter- group relationships (power relations, interactions)
• identify traditional beliefs concerning aquaculture

Prior warning (see box 11)
This survey is in fact an interview with a reduced number of actors representing the types of aquaculture identified at the beginning of the approach and the sector's stakeholders. Actors must be selected on the basis of their knowledge of the sector and of their availability. The survey data on aquaculture farms must be fully assimilated before starting this interview which must be conducted with as little guidance as possible.

Structure of the interview
The interview is structured around discussion "themes" and an interview table rather than being question-based sensu stricto. The questions presented here must therefore be used to start or "re-start" the discussion.
The interviewer can conduct the interview in the order he/she chooses on the condition that not too many details on sustainable development are given before questioning actors on this theme.
In order to find out the representations actors have of sustainable development, this interview guide endeavours to distinguish systematically between the four dimensions of sustainable development i.e. technical, economic, social and governance.

These interviews target three types of actors: (1) actors from the sector (feed suppliers, hatchery owners, veterinary surgeons, wholesalers, processors etc.), (2) institutional actors (State services, professional organisations, research, supervisory structure, NGOs etc., (3) fish-farmers. An interview guide is suggested below for each type of actor, which takes into account the position of this actor within the sector so that their specific representations can be duly recorded.

INTERVIEW GUIDES

1. Interview with actors from the aquaculture value chain

I.- The position of the actor within the value chain and the organisation

Position of the actor within the value chain: What are your activities and your place within the value chain? Since when? Organisational chart and brief history.

II.- Opinion on aquaculture

Aquaculture support and promotion policies to be put into place: What do you think of (or what are the characteristics of) aquaculture development in the last ten years? How do you imagine aquaculture in ten years time? Given the previous statement and this outlook, what type of aquaculture should be preferred? In order to promote this type of aquaculture, what types of interventions and systems should be set up? (meaning to allow this type of aquaculture to develop: subsidies, accompanying measures, training …) ; Which types of farm (and which zones) are likely to fit with this model? What are the consequences for the region? What might best be done to reduce negative effects or to promote positive ones (landscape, quality of life in the rural environment)? What can/should be expected in the social, economic and ecological areas?

III.- Opinion on sustainability

- Approach the decisive factors for sustainability with respect to the four dimensions (this is the opportunity to mention quickly that Sustainable Development is dealt with via its four dimensions, without overly insisting on definitions which could influence perceptions).
- What is the actor's position with respect to the sustainability of aquaculture activity (the sector and all related activities): economic aspects; what seems really important to you today for aquaculture activity from the economic point of view? environmental aspects: how do you see the relationships between aquaculture activity and the environment? social aspects: product consumption, image of the activity, human resources.
- What impacts would the implementation of sustainable aquaculture development policies have on your activity? from an economic point of view: profitability, turnover, debt. from a work organisation point of view: workload, employment etc. from the point of view of social relationships: new relationships with other producers and consumers. at the regional level: benefit from labels etc.
- What is Sustainable Development for you? (to help the actor being interviewed, it might be suggested to him/her to define SD using: a word, a philosophy, a means to guide the activity, a social and political responsibility?). Where did you first hear of SD?
- Involvement: Are you currently involved in the definition of criteria, standards, indicators for SD? Do you think it would be useful for you to be involved in such a process? At which level? Who should control its implementation?

2. Interviews with institutional actors and professional representatives (administrators, NGOs, representatives of professional associations of fish-farmers, researchers, advisers …)

I.- The position of the actor within the sector and the organisation

Position of the actor within the institution or the organisation: What are his functions and his position with respect to the institution? Since when? Organisational chart and brief history of the institution.

II.- Opinion on aquaculture

- Give 5 words to characterise aquaculture as it is now.

- Representations the actor has of aquaculture's functions: What are (were) the functions of aquaculture? What are aquaculture's main impacts on the region?

- Do you think that public aid is: relevant or effective to control the negative or positive impacts of aquaculture activity?

- Do you think that the standards produced by the public authorities are relevant or effective to control the negative or positive impacts of aquaculture activity?

- Aquaculture support and promotion policies to be put into place: What impacts do general development policies have on aquaculture? What do you think of (or how would you describe) aquaculture evolution over the last ten years? Given the previous statement, what model should be preferred? (What are the challenges facing aquaculture over the next ten years?) What types of aquaculture system should be preferred to address these challenges? What might best be done to reduce negative externalities or to promote positive ones? What can be expected in the social, economic and ecological areas?

III.- Opinion on sustainability

- What is Sustainable Development for you? a word, a philosophy, a means to guide the activity, a social and political responsibility?

- What is Sustainable Development for your institution?: a word, a philosophy, a means to guide the activity, a social and political responsibility?

- Has sustainable development changed the organisation and the alliances of your institution? What new resources have been made available to implement or accompany sustainable development? What concrete actions has the institution implemented in line with SD?

- How do you think sustainable development actions should be put into place? By leaving the State the responsibility to produce standards? Or by involving actors in their production? Are incentive mechanisms necessary? How should the control be organised?

3. Interview with fish-farmers

This interview must use the data resulting from the survey of aquaculture farms. The fish-farmers targeted by the interviews come from the fish-farmers' group interviewed during the surveys of enterprises.

I.- The position of the actor within the sector and the organisation

At the time of the interview the two following points must be known by the *interviewer.*

1. Situation of the interviewee: What are your activities? Specialised in aquaculture, aquaculture and agriculture, aquaculture and livestock, aquaculture and commerce, … Origin (rural, agricultural or not) Family status (Age, Number of children, Does he have a successor?) Training (level of training and on-going training). Professional itinerary. Responsibilities in PAO (professional agricultural organisation), associations and political institutions (past and present).

2. Description of the enterprise: The main components of the system (land ownership, type of rent ....); The main methods of supply, reproduction, fry purchase (post-larval shrimps…); sales policies

II. Opinion on aquaculture

Opinion of the fish-farmer of the activity: How does the fish-farmer see the evolution of the activity over the last ten years? How does the fish-farmer see its future in the next ten years? How does the fish-farmer see the evolution and the dynamics of his/her region?

III. Opinion on sustainability

Approach the decisive factors for sustainability with respect to the four dimensions: economic aspects: what seems important to you today for your enterprise and your activity from an economic point of view? environmental aspects: how do you see the relationships between your activity and the environment? social aspects: what seems important to you in the social area? (product consumption, image of the activity, human resources, relationships with the neighbourhood), institutional aspects (development of participatory systems, monitoring-evaluation system concerning sustainable development actions, etc.)

IV. Opinion on sustainable development

- Have you heard of Sustainable Development? Where and when? How do you define Sustainable Development? What principles underpin Sustainable Development? Do you know the criteria, indicators or standards of Sustainable Development? Do you know the origin of this concept? Do you try to apply it (the definition) to your production unit?

- About aquaculture functions and Sustainable Development impacts (present situation): What are (were) the functions of aquaculture? From a social viewpoint: How would you define aquaculture in your zone? (identity-strengthening activity, prestige, leisure, cultural activity). From an economic viewpoint: What is the contribution of aquaculture to your region? (source of income, contribution to local employment, ...). From an environmental viewpoint: What are aquaculture's main impacts on the region? (landscape quality, pollution, ...)

- How do you see the implementation of sustainable development at local level? What changes would be required in the management system?

- Do you think that public aid is adapted to your needs? Do you think that the standards produced (for aquaculture) by the authorities are effective to guide the activity? What do you think of labels or quality standards for aquaculture? (distinguish between quality standards imposed by the marketing sector and those relating to producer initiatives to become stronger and more organised or target new markets).

APPENDIX 3
Model of descriptive sheet for indicators

A sheet should be established for each indicator.

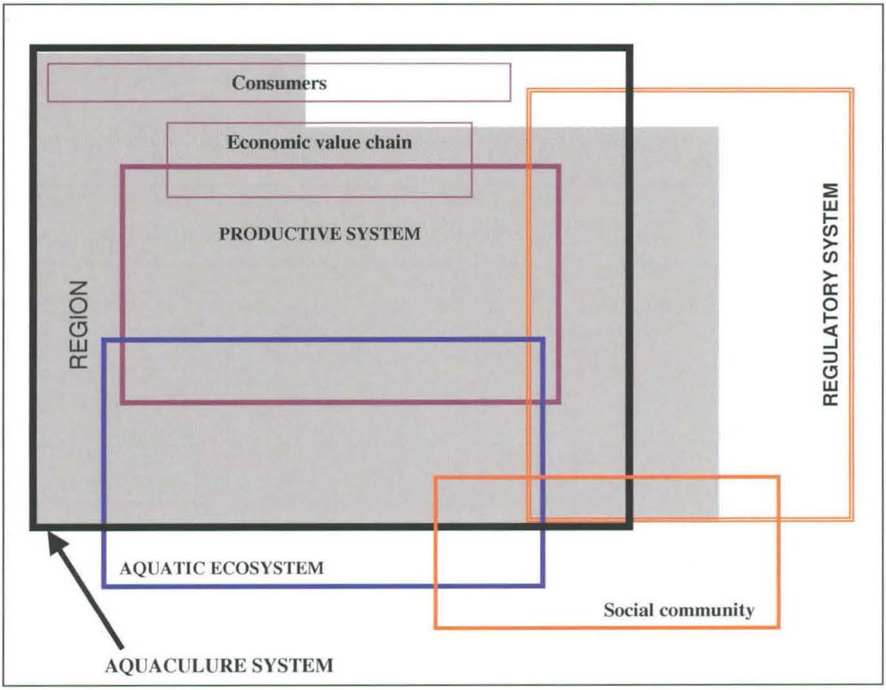
These sheets are a kind of “identity card” for indicators which, as for meta data sheets, by indicating their nature and the way they were built, makes it easier to use them and to assess their reliability.

Indicator title	
Indicator number	This number corresponds to a classification code of the indicator in the database allowing rapid identification.
Measurement unit	Detail of the unit used to measure the indicator.
Origin	Relationship of the indicator to the principle and criterion it refers to (in some cases an indicator can refer to several criteria or principles).
Sustainable development dimension	Specifies the sustainable dimension(s) the indicator refers to.
Meaning of this indicator	Specifies the factor or the variable monitored by the indicator.
Interpretation of its variation	Meaning of the variation in relation to sustainable development.
Indicator limits	Restrictions linked to indicator scope and reliability.
Relationships with other data or indicators	Synergy and complementarity with other indicators.
Sector or region	Sectoral (aquaculture sustainability) or regional (contribution to regional sustainability) nature of the indicator.
Source of data, availability and potential cost	Mode of access to data: statistical sources (database name and status) and cost of access.
Measurement scale	Spatial scale of indicator measurement.
Variation and trend	Type of evolution over time: linear, with thresholds, existence of strict limit values ...
Value of the indicator with reference to the date	Most recent available value(s) and date.
Indicator threshold level	Characteristics of sustainability classes according to the selected scale (from 1 to 5 for example) and indicator calculation and correspondence methods.
Data frequency	Time step for datum availability and indicator measurement.
Current use of data	Current use of selected datum and datum ownership.
Objective to be reached	Sustainable development objective concerning the relevant variable (set through negotiation or with respect to an action plan).
Indicator category	Indicator classification according to reference categories: pressure indicators; state indicators and response indicators.
Further observations	Further observations improving indicator understanding.

APPENDIX 4
Definition of aquaculture systems

The study of aquaculture systems complements the analysis of actors' representations. It requires an appropriate approach. By extending agriculture and husbandry research findings, an analytical framework was established for aquaculture systems (Rey-Valette et al., 2008) making it possible to represent sustainable development by linking all the factors relating to productive systems, regulatory systems and the region (figure). With these three dimensions in mind, sustainability can be considered from two complementary and interactive viewpoints: the sustainability factors for aquaculture enterprises themselves and the contribution that aquaculture systems make to the sustainability of the host areas.

Presentation of the systemic analytical framework for aquaculture systems



* The shading refers to the regional part of the aquaculture system

Rey-Valette H., Clément O., Mathé S., Lazard J., Chia E., 2008. Un cadre pour analyser le développement durable des systèmes aquacoles littoraux. Communication au colloque international pluridisciplinaire : « Le littoral Subir, Dire, Agir », Lille 16-18 janvier 2008.

GUIDE TO THE CO-CONSTRUCTION OF SUSTAINABLE DEVELOPMENT INDICATORS IN AQUACULTURE

It certainly cannot be said that aquaculture has ignored sustainable development, judging by the number of standards, guides and indicators devoted to it, produced mainly under the aegis of international organisations such as FAO, the European Union and some NGOs. However, these continue to be perceived in large measure as constraints rather than as shared objectives by the actors in the field. Faced with this situation, which is not specific to aquaculture but on the contrary quite general regardless of sector, context or scale, this guide seeks to propose a generic approach that through a collective process, i.e. a joint construction, promotes the implementation and the appropriation of sustainable development.

What makes this approach original is not only the participatory nature of the construction, which brings the actors together and takes into account their representations, but also the regional nature of the approach which includes both aquaculture systems and their host areas. It is based on a selection process that nests principles and criteria and which, by linking indicators to the actors' issues and representations, encourages their appropriation of both sustainable development and the indicators produced.
Designed in the form of an instruction manual that is as flexible as possible, the approach alternates various sequences in order to modulate the range and the involvement of stakeholders and to emphasise the collective learning process.

This guide is the fruit of fieldwork undertaken by a group of French researchers in partnership with teams of scientists and actors in France, in Europe and in Southern countries (Cameroon, Indonesia and Philippines). Aquaculture systems, representative of a broad range of farming systems and of governance mechanisms, were studied.

This guide is intended for aquaculture producer groups, supervisory administrations in the sector, as well as research bodies, NGOs,... and any group wishing to implement sustainable development in aquaculture or in any other domain. It may also be very useful to teachers and students who wish to study how aquaculture works in a given region.

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