FAO Fisheries Report No. 861 FIEP/R861 (En)

ISSN 0429-9337

Report of the

EXPERT CONSULTATION ON THE ASSESSMENT OF SOCIO-ECONOMIC IMPACTS OF AQUACULTURE

Ankara, Turkey, 4–8 February 2008

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2008

ISBN 978-92-5-106041-4

PREPARATION OF THIS DOCUMENT

This Consultation was organized in response to the recommendations of the second and third sessions of the Committee on Fisheries (COFI) Sub-Committee on Aquaculture, and the twenty-seventh session of COFI.

Recognizing the growing importance of aquaculture and the need to improve its socio-economic benefits, the second session of the Sub-Committee on Aquaculture meeting in Trondheim, Norway, in August 2003 recommended FAO to undertake a "Thematic evaluation of the social and economic impacts of aquaculture".

The issue of socio-economic impacts of aquaculture was again raised at the Sub-Committee's third session in New Delhi, India, in September 2006, when FAO was asked to organize an intersession "Expert Consultation on the Assessment of Socio-economic Impacts of Aquaculture" with the participation of professional aquaculture and resources economists. The mandate given to this Consultation was to "agree on a widely accepted methodology for assessing socio-economic impacts of aquaculture and to determine future needs for socio-economic analyses, assessments and indicators", specifically for aquaculture. The twenty-seventh session of COFI, which met in Rome in March 2007, endorsed its Sub-Committee's recommendation while emphasizing the urgent need for such a Consultation.

The Consultation was organized and convened by the Development and Planning Service (FIEP) of the Fisheries and Aquaculture Economics and Policy Division, FAO Fisheries and Aquaculture Department, under Dr Nathanael Hishamunda's supervision. The FAO Subregional Office for Central Asia in Ankara, Turkey, contributed organizational support.

FAO.
Report of the Expert Consultation on the Assessment of Socio-economic Impacts of Aquaculture. Ankara, Turkey, 4–8 February 2008.
FAO Fisheries Report. No. 861. Rome, FAO. 2008. 53p.

ABSTRACT

This Expert Consultation was convened with the aim of identifying socio-economic impacts of aquaculture and a universally acceptable method for assessing them. The goal was also to advise FAO on future work in the area of socio-economics of aquaculture. The Consultation debated on the many positive and negative impacts of aquaculture, including those on land and land-based habitats, water and wild species, the downstream and upstream industries of aquaculture, infrastructure, incomes, employment, food supply, food quality and safety, food access, food stability, human health, education and training, population and demography, and community and social order, and emphasized that these impacts have profound interdependence and far-reaching socio-economic implications, which makes the task of assessing them difficult. There was a wide consensus amongst experts that multiple criteria decision-making (MCDM) framework using analytical hierarchy process (AHP) as a measurement technique is a suitable method for assessing socio-economic impacts in a situation where multiple attributes are important and cannot be easily reduced to a single monetary measure of impacts as is the case in aquaculture. However, because of the tangibles which can be evaluated in monetary terms and the intangibles which are difficult to quantify in monetary value in socio-economics of aquaculture, and given the wide range of impacts to assess as well as various circumstances, experts agreed that there is no single method which could be used to assess the socio-economic impacts of aquaculture. In addition to MCDM using AHP, they suggested that other techniques such as the "costs benefits analysis" (CBA) could also be used depending on circumstances. They recommended that FAO carry out case studies in a certain number of developed and developing countries on assessing the socio-economic impacts of aquaculture using AHP, CBA and another technique in order to test and compare the applicability and results of these methods in assessing socio-economic impacts of aquaculture. It was also recommended to develop a user guide on the implementation of these methods and build capacity in developing countries in using the identified techniques. Other needs for future work in socio-economics of aquaculture were also identified.

CONTENTS

	Paragraphs
INTRODUCTION	1–2
OPENING OF THE CONSULTATION	3–4
ELECTION OF OFFICERS	5
ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE CONSULTATION	6
INTRODUCTION OF THE BACKGROUND, OBJECTIVES, RATIONALE AND EXPECTED OUTCOME OF THE CONSULTATION	7
REVIEW OF THE SOCIO-ECONOMIC IMPACTS OF AQUACULTURE: IDENTIFICATION AND ASSESSMENT METHODS	8–44
FOLLOW-UP ACTION AND FUTURE WORK ON SOCIO-ECONOMICS OF AQUACULTURE	45–46
ADOPTION OF THE REPORT	47

APPENDIXES		**Page**
A.	Agenda	9
B.	List of participants	11
C.	Background document: "*Review of the socio-economic impacts of aquaculture: identification and assessment methods*" (Junning Cai, Ping Sun Leung and Nathanael Hishamunda)	13
D.	Welcome remarks by Mr Tsukasa Kimoto, Officer-in-Charge, FAO Subregional Office for Central Asia (SEC)	49
E.	Outline for the improvement of the background document: "*Review of the socio-economic impacts of aquaculture: identification and assessment methods*"	51

INTRODUCTION

1. The Expert Consultation on Assessment of Socio-economic Impacts of Aquaculture was held at FAO Sub-Regional Office for Central Asia in Ankara, Turkey, from 4 to 8 February 2008.

2. The Consultation was attended by nine experts, three resource persons and one observer, from a wide range of disciplines, experience and geographical areas, including Africa, Asia and the Pacific, Europe, Latin America and North America. They included aquaculture economists, resource economists, agricultural economists, sociologists and aquaculture specialists. The participants are listed in Appendix B. The document placed before the experts is attached as Appendix C.

OPENING OF THE CONSULTATION

3. The Consultation was called to order by the Technical Secretary, Mr Nathanael Hishamunda.

4. The opening statement was delivered by Mr Tsukasa Kimoto, FAO Representative in Turkey, a.i., and Coordinator, a.i., of the FAO Subregional Office for Central Asia and FAO Representative in Turkey. In welcoming participants, Mr Kimoto reflected on the complexity of the issues related to the question of socio-economic impact assessment in aquaculture. On the one hand, he underlined the important and growing socio-economic role of aquaculture in terms of supplying fish and other aquatic products for food, providing employment and income to millions of people around the globe and contributing to many countries' economic growth and poverty reduction. On the other hand, he recalled that these impacts are a constant source of public debates, citing as examples, the possible distributional bias and negative impacts of aquaculture, especially through environmental disruption, which can negatively affect society as a whole. He emphasized the two major tasks of the Consultation; namely, to identify the socio-economic impacts of aquaculture, and to develop simple, easy-to-use, yet robust and universally accepted method for measuring these impacts. In closing his intervention, he invited experts to assist FAO in this endeavour. Mr Kimoto's opening statement is given in Appendix D.

ELECTION OF OFFICERS

5. Dr Clement Tisdell, Emeritus Professor at the University of Queensland, Australia, was elected Chairperson of the Consultation. He expressed his gratitude to the experts for their confidence in electing him to the Chair. The Consultation selected Ms Tokrisna Ruangrai, Associate Professor and Chair of the Department of Agricultural and Resource Economics, Kasetsart University, Thailand, as its Vice-Chairperson.

ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE CONSULTATION

6. The Consultation adopted the agenda attached as Appendix A. The Chairperson then outlined the timetable for the Consultation.

INTRODUCTION OF THE BACKGROUND, OBJECTIVES, RATIONALE AND EXPECTED OUTCOME OF THE CONSULTATION

7. In introducing this agenda item, the Secretariat recalled that this Consultation constitutes a response to the recommendations of the second and third sessions of the FAO COFI Sub-Committee on Aquaculture, which were held in Trondheim, Norway, in August 2003, and New Delhi, India, in September 2006, respectively. The Secretariat indicated that the growing importance of socio-economic benefits of aquaculture to society (in terms of food security, employment, income, contributions to national economies, etc.), the increasing need to improve these socio-economic benefits, the potential of aquaculture to negatively impact society as it grows (through environmental

disruption, social equity, etc.), and the need for policy-makers wishing to promote aquaculture to have a tool for measuring these benefits and costs before they can make a decision as to whether to promote aquaculture or not, are some of the reasons underlying the holding of this Consultation. The Secretariat outlined the expected outcome of the Consultation as being a report containing a clear and exhaustive identification of the socio-economic impacts of aquaculture, an agreed-upon method for measuring these impacts, a final version of the background document placed before the Consultation, follow-up actions to this Consultation and future work of global or regional interest in socio-economics of aquaculture.

REVIEW OF THE SOCIO-ECONOMIC IMPACTS OF AQUACULTURE: IDENTIFICATION AND ASSESSMENT METHODS

8. The Consultation decided to conduct the discussion on this agenda item according to the suggestions provided in the document "*Review of the socio-economic impacts of aquaculture: identification and assessment method*". The review was done chapter by chapter.

9. In presenting Chapters 1 and 2, the Secretariat recalled that the document placed before them covers four main chapters including "Introduction" and "Identification of socio-economic impacts of aquaculture", Chapter 1 being a short introduction of the document and where Chapter 2 discusses the aquaculture's many impacts on socio-economic impacts as provided for in the literature.

10. The Secretariat also discussed the many positive and negative impacts of aquaculture identified in the literature, including impacts on land and land-based habitats, water and wild species, the downstream and upstream industries of aquaculture, infrastructure, incomes, employment, food supply, food quality and safety, food access, food stability, human health, education and training, population and demography, and community and social order. The Secretariat emphasized that these impacts have profound interdependence and socio-economic implications, which makes the task of assessing them challenging.

11. This presentation was followed by an extensive discussion amongst experts, from which emerged the following conclusion: there was a general consensus that Chapter 1 (Introduction) needs to be substantially extended.

12. The Consultation made the following recommendations to improve the "Introduction" Chapter:

- Define key terms such as "assessment" and "socio-economic impacts".
- Discuss the impacts while avoiding their categorization under "positive" or "negative".
- Relate the assessment of socio-economic impacts of aquaculture to Millennium Development Goals (MDGs) with respect, for example, to the contribution of aquaculture to poverty reduction and sustainable livelihood.
- Clarify from the onset that socio-economic impacts of aquaculture so as to include both tangible impacts which can be evaluated in monetary terms and the intangibles which are difficult to quantify in monetary value, and provide examples of each category.
- Provide the rationale for this whole exercise.
- Discuss externalities in more details, show their linkages to socio-economics and highlight the difficulties and importance of this study.
- Clarify the level of policy making at which the assessment technique being sought will be applied and related.
- Adapt the technique to different levels of economic development (developing countries, emerging economies and advanced economies) and aquaculture production systems and scales.
- Discuss property and customary rights and equity because they can affect socio-economic impacts.

- Use case studies, including boxes, to illustrate the importance of socio-economic impact assessment.
- Provide a summary of the Chapter and the transition to the next.

13. In the course of discussion of Chapter 2 (Identification of socio-economic impacts of aquaculture), the Consultation noted the need for its restructuring and expansion, and made the following recommendation for this purpose:

- Add an introductory paragraph to show the purpose of the Chapter.
- Make a clearer statement of how the impacts described in this Chapter were identified and show how they translate into "social and/or economic" impacts.
- Use a conceptual framework. This framework would not only help understand the nature of these impacts, but also would ensure their in-depth coverage.
- Re-group the current listed impacts in a more rational and coherent manner under additional sub-headings. For this, discuss them under the main umbrella of "capital".
- Discuss the impacts while avoiding their categorization under "positive" or "negative".
- Make a reference to the principles of the Code of Conduct Responsible Fisheries and the principles for social impact assessment as codes of "good" conduct to guide good practice.

14. The Consultation also advised to have, under section 2.4., a sub-section on the socio-economic implications of foreign direct investment in which, the possible socio-economic impacts of corruption in aquaculture would be discussed. With globalisation, large foreign companies are more and more moving in developing countries to invest in aquaculture, and sometimes use bribery as a tool of accessing local productive resources. This can reduce the economic gains (resource rents) of developing nations from their aquaculture resources.

15. The Consultation suggested an expansion of section 2.5 (Infrastructures and facilities), a short discussion on possible negative impacts that aquaculture-created infrastructures and facilities can have on communities and to show how these first-order non socio-economic impacts discussed in this section translate into secondary socio-economic impacts.

16. Concerning sections 2.6 and 2.7 (Impacts on incomes and Impacts on employment), the Consultation recommended that these two sections be combined, and that a separate sub-section be created, where employment along the whole chain of sector (including in the processing), income (including cash and non-cash income) and fringe benefits and income distribution problems would be discussed.

17. It was also recommended to discuss gender, equity and distributional issues, labour standards (wage rates and other working conditions) in aquaculture, and indigenous people and minorities in detail. The claim by some that aquaculture helps the rich instead of the poor will need to be elaborated on.

18. The sections 2.8 (Impacts on food supply), 2.9 (Impacts on food quality and safety), 2.10 (Impacts on food access) and 2.11 (Impacts on food stability) should be combined under a new sub-section "food security". Impact of aquaculture on food stability and prices should also be discussed under this section.

19. The Consultation noted that sections 2.12 (Impacts on human health), sections 2.13 (Impacts on education and training) and 2.14 (Impacts on population and demography) as well as research and technology need to be combined and discussed under a broader heading of "Impacts on human capital". The discussion of impacts on human health should follow the already-established Health Impact Assessment framework and should include some negative health impacts related to aquaculture development such as water-borne diseases.

20. One expert mentioned that the impact of aquaculture on human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) should be examined.

21. A section on impacts of aquaculture on financial capital (Institutional structures) should be created for the discussion of elements such as investment, financial institutions/credit, fiscal policies (taxes and subsidies), and insurance companies.

22. The section 2.15 (Community and social order) heading should be modified following consideration of its content.

23. Three experts shared short presentations on how the ideas in the paper under discussion could be organized. While these presentations were appreciated by the Consultation, they again confirmed the difficulties of fitting all the socio-economic impacts of aquaculture in one flow chart or table. The Consultation found that it would be acceptable to organize the discussion of these impacts around the generally-accepted categories of “capital”/resources (natural, physical, human, social and financial).

24. The presentation of Chapter 3 of the Background document (Methodology) started with a discussion of the stakeholder approach in relation to the impact factors and potential indicators. The Secretariat went on to discuss the possibility of using multiple criteria decision-making (MCDM) techniques to embrace socio-economic factors/criteria in addition to economic efficiency. It was also mentioned that MCDM techniques could be used to circumvent the difficulties in valuing non-market and intangible factors, and that MCDM techniques could facilitate stakeholders’ involvement and provide explicit trade-off analysis.

25. The Secretariat proceeded to show the range of MCDM techniques used in conservation planning based on a recent review paper, and indicated that the most often used techniques were analytic hierarchy process (AHP), multiple attribute utility theory (MAUT) and modified AHP. The AHP was briefly introduced highlighting its hierarchic thinking. An example of a hierarchic tree was shown to illustrate the various levels of the hierarchy representing the overall objective, criteria, factors, stakeholders and alternatives. The idea of identifying priorities from paired comparison was introduced and the allowance for measurement of inconsistency in judgment was touched upon. The ability of prioritizing both tangibles and intangibles using AHP was mentioned. Finally, the pros and cons of AHP technique were briefly discussed. In particular, the problem of rank reversal and cost (time and money) of paired comparison process were emphasized.

26. The Consultation decided first to call for general comments on the Chapter before its discussion by section. The following were formulated.

27. Because there are tangibles and intangibles in socio-economics of aquaculture such as dignity, self-esteem or low crime rates which could result from employment created by aquaculture, and because there is a wide range of impacts to assess as well as various circumstances, there is no single method which could be used to assess the socio-economic impacts of aquaculture.

28. There was a wide consensus that MCDM framework using AHP as a measurement technique is a suitable method for assessing socio-economic impacts of aquaculture where multiple attributes are important and cannot be easily reduced to a single monetary measure of impacts.

29. The Consultation noted that MCDM has its own caveats including rank reversal and being demanding in implementation (time and resources). That said, however, there is some evidence that MCDM is less demanding than any other comparable method such as contingent valuation (willingness to pay and willingness to accept).

30. In addition, limitations of stated preference techniques were highlighted.

31. While supporting AHP as one of the suitable techniques to evaluate socio-economic impacts of aquaculture in particular circumstances, the Consultation proposed to build a stronger case for the use of this technique. Thus they made several recommendations for this purpose which include but are not limited to:

- clarify assumptions underlying the use of AHP;
- highlight the pros and cons of AHP in comparison with other methods such as cost-benefit analysis (CBA);
- bring in case studies/experiences (in several forms including boxes) where AHP has been successfully applied including in fisheries and aquaculture;
- discuss other applications of AHP such as an aquaculture site selection and aquaculture and fisheries management;
- make a comparative table of "situations" and more suitable assessment techniques in the Introduction;
- identify the circumstances more clearly where it is the appropriate assessment technique to use.

32. There was a desire from one expert to clarify how AHP addresses the issue of intergenerational (future generations) equity and the comparison of impacts that occur at different times with different duration.

33. In discussing section 3.1 (A review of literature), the Consultation felt that this sub-section was fragmented, ad hoc and separated from the very purpose it is intended to serve, and needed to be expanded and substantiated.

34. In particular, it was advised to build a continuum between different elements of this section, critically discuss indicators in terms of demonstrating what they are intended to measure (food security, income, health, etc.) and to add a sub-heading on "Intertemporal distribution".

35. Before deciding to discuss MCDM alone in detail, there was a call to report and discuss other techniques which can be used to assess socio-economic impacts of aquaculture, compare them with MCDM in terms of assumptions, what they can do and what they cannot, advantages and disadvantages, and show why, if all these methods are decision-making tools, MCDM is preferred over them when assessing socio-economic impacts of aquaculture.

36. In particular, it was suggested that the sub-section on CBA be expanded in the same way MCDM is covered in the document, including its strengths and its limitations, and that a discussion of the compensation principle be discussed.

37. Concerning the sub-section on "Stakeholders", most experts agreed that this section was too generic, which could lead to the danger of not considering groups at appropriate level of detail. Because the concept of stakeholder can mean different things to different people, and stakeholders can change with time, the Consultation underlined the need to clearly define this concept and to correctly select stakeholders when assessing socio-economic impacts and to specify the method used for this selection. Regarding the definition, they recommended connection with the already-established definitions such as the ones used by development agencies.

38. Discussing the assessment of impacts of aquaculture on Stakeholders' well-being, the Consultation noted that the static nature of AHP technique is a major limitation.

39. There was a long discussion on how to determine the net impact on stakeholders' well-being. The problem arises because Economists still have serious difficulties with interpersonal utility comparisons and, hence, aggregation may be inappropriate.

40. The following question was then raised: if aggregation is not undertaken, then, how does the method help policy-makers take the decision? Several answers were suggested, including combining some groups that have similar ordering of attributes, asking policymakers to rank attributes and to take the decision according to the stakeholders that they think are more important. In fact, for policy-makers the des-aggregation may be more interesting than aggregation.

41. In discussing Chapter 4 (Application of the suggested methodology), there was a wide agreement to change this title as there was no such single appropriate method suggested to tackle the issue at hand.

42. The Consultation recommended changing the title to "Illustration of selected assessment methods". This chapter would be expanded through the use of case studies which illustrate how different methods could be used to assess socio-economic impacts of aquaculture in different situations. Situations could include production scales, production systems, economic development levels and sector development levels. Methods used could include CBA, AHP and others.

43. In closing the discussion on the document, the Consultation agreed that multi-attribute analysis, in particular AHP, is a promising socio-economic assessment technique, but more guidance is needed on its strengths and limitations and about when it can be appropriate to be applied, especially in developing and transitional countries.

44. Following the experts' suggestions, the Secretariat drafted a new outline which would be followed to re-organize and improve the document. The outline, which was also discussed at some length by Experts, is in Appendix E. Experts noted that the plan for the new version of the document has been modified in the light of the Expert Consultation. As a result, significant improvements will be made to the original document. The authors were encouraged to use the new outline, but not bound it.

FOLLOW-UP ACTION AND FUTURE WORK ON SOCIO-ECONOMICS OF AQUACULTURE

45. The Consultation recommended the following immediate action to FAO:

i. Carry out case studies in a certain number of developed and developing countries on assessing the socio-economic impacts of aquaculture using CBA, AHP and another technique in order to test and compare the applicability and results of these methods in assessing socio-economic impacts of aquaculture.
ii. Develop a user guide on the implementation of these methods and build capacity in developing countries in using the identified techniques.

46. The Consultation also recommended that the following important tasks will need to be undertaken in aquaculture:

i. Assess the impact of aquaculture on incomes, employment and working conditions.
ii. Conduct in-depth study on employment in aquaculture (this could be an FAO/ILO joint activity).
iii. Conduct further social research in aquaculture development, including the management of social issues.
iv. Conduct studies on health assessment from a socio-economic point of view.
v. Studies on the impact of supermarket/large retail groups (in developed as well as developing countries) on the development and financial feasibility of small-scale aquaculture farmers in Africa.
vi. Further analysis of the contribution of aquaculture to the fulfilment of the MDGs.
vii. Studies on natural resource rents, property and customary rights in relation to aquaculture.
viii. Studies on the level of concentration in the industry (market and production), impacts of foreign investment on aquaculture, in particular in the context of globalization and the costs of compliance with international import standards for lower-income countries.

ix. Research on the socio-economic implications of climate change impacts on aquaculture.
x. Increase its attention to awareness raising and capacity building on the socio-economic aspects of aquaculture, including supporting developing countries in the collection and analysis of socio-economic data and information related to aquaculture.
xi. Develop perspectives from institutional economics (particularly new institutional economics) on the problem of aquaculture impact assessment.
xii. Promote collaboration among regions, countries and organisations on research and capacity building on socio-economic aspects of aquaculture.
xiii. Undertake mainstream socio-economic impact studies within its work on aquaculture.

ADOPTION OF THE REPORT

47. The report of this Consultation was adopted on 8 February 2008.

APPENDIX A

Agenda

1. Opening of the Consultation
2. Election of Officers
3. Adoption of the agenda and arrangements for the Consultation
4. Introduction of the background, objectives, rationale and expected outcome of the Consultation
5. *“Review of the socio-economic impacts of aquaculture: identification and assessment methods”*
6. Follow-up action and future work in socio-economics of aquaculture
7. Adoption of the report

APPENDIX B

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APPENDIX C

Background document:
Review of the socio-economic impacts of aquaculture: identification and assessment methods

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CONTENTS

Page

1. INTRODUCTION 15
2. IDENTIFICATION OF SOCIAL-ECONOMIC IMPACTS OF AQUACULTURE 15
2.1 Impacts on land and land-based habitats 15
2.2 impacts on water 16
2.3 impacts on wild fish stocks 17
2.4 Impacts on other industries 18
2.5 Impacts on infrastructure and facilities 18
2.6 Impacts on incomes 18
2.7 Impacts on employment 19
2.8 Impacts on food supply 19
2.9 Impacts on food quality an safety 19
2.10 Impacts on food access 20
2.11 Impacts on food stability 20
2.12 Impacts on human health 21
2.13 Impacts on education and training 21
2.14 Population and demography 21
2.15 Community and social order 21
3. METHODOLOGY 22
3.1 A review of literature 22
3.1.1 Setting *22*
Plan: issues, objectives and assessment process *23*
Conceptual framework *23*
Empirical framework *25*
3.2 A suggested methodology for assessing the social framework: stakeholder approach 31
3.2.1 The conceptual framework *31*
3.2.2 The empirical framework *34*
3.2.3 The AHP method *35*

4. APPLICATION OF THE SUGGESTED METHODOLOGY 37
REFERENCES 41

TABLES
1 Indicators and measures of aquaculture's impact 27
2 Source of aquaculture impacts on stakeholders 33
3 Impacts of aquaculture on producers and local residents 36
4 Impact of shrimp farming on farmer's socio-economic well-being 38
5 Scale system for pair-wise comparisons 38
6 Results of general pair-wise comparisons 38
7 Results of pair-wise comparisons of the scenarios with and without aquaculture 39
8 Relative weights of general and scenario pair-wise comparisons 39
FIGURE
1 Conceptual model detailing the effects of coastal ecosystem health on aspects of human well-being 24

1. INTRODUCTION

Aquaculture is “the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as hatching, stocking, feeding, rearing to marketable size, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated.” (FAO, 1997a).

Aquaculture can contribute to the economy through supplying high-quality foods and other fish products, creating incomes, and providing jobs. The economic contribution of aquaculture has been growing. Stationary or even declining supply of fish from captured fisheries requires aquaculture to assume a more important role in satisfying the increasing future fish demands induced by rapid population and income growth (FAO, 1996; 1998; 2000; 2002). In addition to its own economic contribution, aquaculture can also induce economic contribution of other sectors that supply materials to aquaculture or use aquaculture products as inputs. However, as aquaculture competes for economic, social, physical and ecological resources with other industries, its development may have negative impacts on other industries such as fisheries, agriculture, and tourism.

As a resource-based activity utilizing land and land-based resources such as mangroves, water and water bodies, and wild species (for seed, fry and broodstock), aquaculture has significant environmental impacts. Aquaculture’s impacts on the environment tend to have social-economic implications.

In addition to its impacts on the society through the economic and environmental dimensions, aquaculture also affects the surrounding community through its impacts on population demographics and community relationship.

The goal of this project is to develop a common method to assess the social-economic impacts of aquaculture. To achieve this goal, this document: (1) identifies both positive and negative socio-economic impacts of aquaculture; (2) reviews the existing methods of social-economic impact assessment; and (3) recommends conceptual and empirical frameworks and explain their use in assessing the social-economic impacts of aquaculture.

In the remainder of this document, we first review the impacts of aquaculture identified in the existing literature and then the existing methodologies of assessing the social-economic impacts of aquaculture. Based on the impacts identified and the methodologies reviewed, we suggest a systematic approach for assessing the social-economic impacts of aquaculture. This “stakeholder approach” uses social-economic well-being of stakeholders as a focal point for impact assessment and applies the analytical hierarchy process (AHP) method to capture the tradeoffs among the multiple dimensions of stakeholders’ well-being under the influence of aquaculture through many factors. At last, we use an example to illustrate the application of the AHP method in our evaluation.

2. IDENTIFICATION OF SOCIAL-ECONOMIC IMPACTS OF AQUACULTURE

In this section we review the impacts of aquaculture identified in previous studies. We not only focus on aquaculture’s direct impacts on the economy and society, but also pay attention to the social-economic implications of aquaculture’s impact on the environment and ecosystems. We first describe each possible impact of aquaculture and then discuss the welfare implications of each impact on different stakeholders.

2.1 Impacts on land and land-based habitats

Land is required for establishing aquaculture farms and associated infrastructures. As far as the supply of aquatic protein is concerned, aquaculture can be a more economic way to utilize land and land-based resources in some cases, which is evident by the high productivity of both freshwater (e.g. carps and tilapia) and mariculture (e.g. shrimp and salmon). Aquaculture can also utilize land unsuitable for other agricultural activities. Aquaculture also may be complement to other farming activities (e.g. fish-rice culture). In addition, nutrient-rich mud at the bottom of aquaculture ponds can be utilized to a limited extent to fertilize nearby agricultural land (FAO, 1987).

However, aquaculture production systems and technologies adopted for short-term high profits could have detrimental and irreversible impacts on the quantity and quality of land (ADB/NACA, 1998). For example, intensive shrimp farming could pollute shrimp ponds and make them toxic to such a degree that after about 5 to 10 years, they have to be abandoned and cannot be used for agricultural production or any other purpose (Boromthanarat, 1995).

Aquaculture and related activities can lead to degradation or destruction of wetlands, lagoons, or mangrove forests, loss of terrestrial habitats, soil salinization, and land subsistence as a result of extraction of underground water (Cruz-Torres, 2000). Such environmental impacts have resulted in significant social-economic consequences. For example, excessive pumping of water from underground aquifers for shrimp and eel culture in Taiwan has reduced agricultural productivity through salt-water intrusion, and caused damage to transportation and other infrastructure (GESAMP, 1991).

Besides, aquaculture competes for land resources with other activities such as fisheries, agriculture, livestock farming, woodcutting, fuelwood gathering, recreation, settlement and conservation (FAO, 1997b; Barraclough and Finger-Stich, 1996). For example, a survey on shrimp farming in Thailand found that 49 percent of the land used by shrimp farms were rice fields and 27.5 percent used to be orchards (Jenkins *et al*., 1999).

The impacts of aquaculture on mangrove forests are the well-documented cases of aquaculture impacts on land-based habitats. Mangrove forests are productive ecosystems providing breeding grounds for fisheries, water cycle regulation, erosion control, and buffer zones against floods, as well as the production of forest-related goods and services (Barraclough and Finger-Stich, 1996; GESAMP, 2001). However, the communally used resources provided by mangroves, from which products for subsistence and for sale are harvested, tend to be destroyed because of construction of shrimp farms (Banarlung, 1990; Jenkins *et al*., 1999). For example, about 25 percent of mangrove hectares in Thailand (a major shrimp farming country) have been lost because of activities related to aquaculture development (GESAMP, 1991). Large-scale mangrove conversion for shrimp and fish farming in Ecuador and many Southeast Asian countries have also caused saltwater intrusion into groundwater and agricultural land and displaced rural communities used to depend on mangrove resources for their livelihood (GESAMP, 1991).

2.2 Impacts on water

Water is essential for growing fish. Aquaculture can have positive impacts on water quality. For example, freshwater culture of carps, catfish, and tilapia can help reduce harmful organic waste in the water. Nutrient water generated by aquaculture can also become feed for wild species (e.g. molluscs) and boost local fisheries (Hambrey, 1999).

However, irresponsible aquaculture can have negative impacts on the supply and quality of water (ADB/NACA, 1998). For example, excessive use of underground water in Taiwan has caused reduction of fresh-water supply for agricultural, industrial, and communal uses (GESAMP, 1991). The use of trash and shellfish as feed, as well as overusing artificial feed can easily lead to degradation of surrounding water and sediment quality, especially in sheltered areas with little water flow and tidal flushing, and particularly where aquaculture development is close to or above carrying capacity (STREAM, 2003). Nutrient enrichment and eutrophication can be caused by the soluble inorganic nutrients (nitrogen and phosphorus) discharged by intensive fish and shrimp farming; and the release of dissolved organic compounds and other components such as vitamins into the receiving water bodies could influence the growth and toxicity of particular species of phytoplankton (GESAMP, 1991). For example, eutrophication and frequent phytoplankton blooms have occurred in coastal marine waters in Mexico where shrimp farming activities are concentrated (Cruz-Torres, 2000). Medicines, disinfectants, and antiseptics in aquaculture are other factors causing the degradation of surrounding waters. For example, the excessive use of $CuSO_4$ for curing shrimp diseases has caused extremely severe pollution in the water of the Pearl River Delta in China (IISD, 2004).

Aquaculture's impacts on water supply and quality tend to affect other stakeholders in the community and hence become a destabilizing factor. In Thailand, there have been conflicts among shrimp farmers and confrontations between shrimp farmers and other local farmers and residents over the discharge of effluent water into public waterways and coastal areas, the intrusion of saline water into rice fields and the salinization of canals (Jenkins *et al*., 1999)

2.3 Impacts on wild fish stocks

By supplying more affordable aquatic products, aquaculture can reduce the pressure on fisheries and help preserve wild fish stocks.

Aquaculture's impacts on the environment can also be beneficial to wild species. For example, nutrient water generated by aquaculture can help increase the production of bivalve molluscs and boost local fisheries (Hambrey, 1999). In addition, aquaculture can also enhance wild fish stocks through restocking programmes. However, aquaculture can also have negative impacts on wild fish stocks through harvest of wild stock, use of wild fish for feeds, and its impacts on the environment (Fletcher *et al*., 2004).

Many important cultured species (such as marine shrimp, milkfish in the Philippines, yellow tail in Japan, and eel in Asia and Europe) still rely on the collection of brood stock or seed from natural populations (Bartley, 1998). Even when hatchery seeds or fry are available, wild seeds and fry are still preferred because they are healthier and more resistant to diseases (Cruz-Torres, 2000). The process of wild stock collection for aquaculture may not only reduce the stock of the cultured species but also tends to affect other wild species through by-catch (Cruz-Torres, 2000). The reliance of aquaculture on wild stock collection has resulted in conflicts over the exploitation of fisheries resources. In the shrimp farming region of Mexico, there have been confrontations between fish cooperatives and shrimp-farm personnel; in some instances, fishermen showed up with truncheons to confront marine biologists and other shrimp farms personnel to demand that they stop harvesting shrimp larvae (Cruz-Torres, 2000).

The expansion and intensification of aquaculture increases its reliance on artificial feeds (New and Csavas, 1995). In turn, the production of artificial aquaculture feeds relies on captured fish (Tacon, 1997). There are concerns over the efficiency of aquaculture using wild fish stocks. Intensive aquaculture tends to require more fish biomass inputs than the farmed fish produced. According to Naylor *et al*. (2000), for the ten types of fish most commonly farmed, an average of 1.9 kg of wild fish is required for every kilogram of fish raised on compound feeds. Only three of the ten types of fish – catfish, milkfish and carp – require less fish as inputs than is ultimately harvested. In contrast, carnivorous species require 2.5–5 times as much fish biomass as feed as is produced. With the predicted global increase in aquaculture production, the use of fishmeal in aqua feed is expected to increase by more than 5 percent (from 2.87 to 3.02 million tonnes from 2002 to 2012) while the demand for fish oil will increase by more than 17 percent (from 0.83 to 0.97 million tonnes) from 2002 to 2012 (Tacon, Hasan and Subasinghe, 2006). About 6 million tonnes of the so-called **trash fish** are used as direct feed in aquaculture annually, particularly in marine aquaculture. It is projected that by the year 2013, China alone will require 4 million tonnes of "trash" fish to sustain its marine cage culture. Yet, the supplies of trash fish are declining; the use of "trash" fish in aquaculture does not look sustainable. As mentioned in Section 2.2, the use of "trash" fish may also affect the wild stocks through its adverse environmental effects and biosecurity risks (STREAM, 2003).

In Section 2.2 we have discussed the impacts of aquaculture on surrounding water and water bodies. Aquaculture-induced pollution tends to negatively affect wild fish stocks. Aquaculture escapees are another factor that can negatively affect wild species stocks through disease dissemination, genetic contamination, competition for food and shelter, and food chain impacts(APEC/FAO/NACA/ SEMARNAP, 2001).

The impacts of aquaculture on wild fish stocks have profound social-economic consequences; one of which is to affect the well-being of local stakeholders whose livelihoods depend on wild fish stocks. It has been reported that in an Indian coastal village, one year of operation of nearby aqua farms has resulted in the reduction of local fishermen's average catch ten folds. In Bangladesh, it has been reported that the destruction of mangroves and the building of dikes for shrimp farming have resulted in an 80 percent drop in fish capture by local fishermen. There have been many protests by fishermen against loss or restriction of their traditional access to the coastal area, or the disappearance of wild crustaceans and fish stocks (Barraclough and Finger-Stich, 1996).

2.4 Impacts on other industries

Aquaculture can be a pivotal industry that induces the development of other industries. For example, Zanzibar, a commercial seaweed farm in Tanzania was a main client of a local fertilizer manufacturing company and a main supplier of a local pharmaceutical firm. Aqualma, a shrimp farm in Madagascar, purchased from local suppliers at least 40 tons of lime per month from a local supplier, sizable quantities of chicken manure to fertilize the ponds, and food for the workers, including more than half a ton of beef per month, rice, vegetables and other items; in addition, the company's import demands represented about 50 percent of the activities in a port nearby (Karmokolia, 1997). The catfish industry in Nigeria has also induced the development of local feed manufacturers (Hishamunda, N. 2004).

Because of its impacts on the environment, aquaculture development tends to negatively affect the development of industries such as fisheries, agriculture, forestry and tourism with which it competes for natural and environmental resources (Barraclough and Finger-Stich 1996). In Section 2.1, 2.2, and 2.3 we have discussed several cases of conflicts between aquaculture and fisheries or agriculture and the social-economic implications of those conflicts. As commercial aquaculture are usually located on pristine coastal areas where natural resources are clean and cheap, it tends to affect the tourist industry which has the same preference for such sites. The commercial shrimp farms with images that are hardly deemed aesthetic with its accessory facilities, not mentioning its physical impacts on surrounding water and ecosystem (Barraclough and Finger-Stich, 1996; Deniz, 2001).

2.5 Impacts on infrastructure and facilities

Aquaculture development can help facilitate the expansion and upgrading of roads, electricity supplies, water supplies, telephone and other communication, and transportation infrastructure (NACA, 1994; Funge-Smith, 1997), and vice versa. For example, the Aqualma project in Madagascar has contributed to local communities with "US$1.6 million worth of roads, utilities, communications, housing and amenities" (Karmokolias, 1997). In Zambia, Kafue Fish Farms contributed to road construction in the farm vicinity through financial and other supports (Hishamunda, 2004). Coastal shrimp farming in Thailand, in the early stage of development, increased rapidly in the area with access to road and electricity.

2.6 Impacts on incomes

Aquaculture, especially commercial aquaculture, generates income to stakeholders. These revenues are derived form of wages, interests, profits, tax revenues, and the sale of value-added products from fish farming activities, or through the value-added from aquaculture support industries, or aquaculture induced industries/activities (Karim *et al*., 2006).

A detailed discussion on aquaculture's positive contribution to incomes can be found in our previous report on "Commercial aquaculture and economic growth, poverty alleviation and food security: an assessment framework" (Cai, Leung and Hishamunda, in press).

However, through its competition for natural resources and its externalities to the ecosystem, aquaculture can negatively affect incomes generated by other industries, such as fisheries, agriculture, forestry and tourism (FAO, 1997b).

2.7 Impacts on employment

Aquaculture, especially commercial aquaculture, can provide employment not only through fish farming activities *per se*, but also through the employment opportunities generated in the aquaculture support industries or those induced by aquaculture.

A detailed discussion on aquaculture's positive contribution to employment can be found in Cai *et al.*, 2007.

Local communities may not be the sole beneficiary of the incomes generated through the application of aquaculture technologies. Employees from other locales may stand to benefit more from aquaculture investments in a given community. For example, an estimated 75 percent of the shrimp farmers in Khulna and Satkhira districts of Bangladesh were not natives of the coastal areas during the early 1970s. Many of the shrimp farm owners in the country came from the business or service sector; and they leased land from local farmers and the government. As they flooded areas beyond the leased land, forcing other land users out of the area and into less secure or more difficult income earning activities (Sultana, 1994).

2.8 Impacts on food supply

Aquaculture is "an important domestic provider of much needed high-quality animal protein and other essential nutrition (generally at affordable prices to the poorer segments of the community)" (Tacon, 2001). The sector is becoming increasingly important in supplying fish to feed the world. With 106 million tonnes produced in 2004, aquaculture produced 43 percent of the fish consumed globally (FAO, 2007). In addition, aquaculture can have positive impacts on other food supply sources. For example, nutrient water generated by aquaculture can help increase the production of other species such as bivalve molluscs which may boost local fisheries production (Hambrey, 1999).

However, through its adverse impacts on other food suppliers, aquaculture can negatively affect food supply. Aquaculture use of land can reduce the availability of this resource for agricultural activities.

By using fisheries resources for seed and feed, aquaculture can reduce the supply of food fish from the wild. Aquaculture can also affect yields from fisheries resources through its use of pesticide, antibiotic and other chemicals, its water and solid wastes, and its escapees (Boyd, 1999).

2.9 Impacts on food quality and safety

In general, aquatic products are an important source of high-quality animal protein, particularly for developing countries (FAO, 1997a).

Aquaculture can improve food quality by affecting the nutrition value, colour and appearance, smell and taste, texture, storing capacity and other characteristics of aquatic products under culture (Hasan, 2001). For example, more nutritious salmon fillets can be produced by modification of the dietary composition of farm salmon (Hasan, 2001). In Southern China, a kind of farmed grass carp has especially crunchy texture because of the adding of broad bean in the feed (Luo, 2004).

Since aquaculture products are produced under controlled environment, aquaculture can help avoid or alleviate food safety problems derived from contamination by heavy metals, or harmful chemicals sometimes found in capture fishery, hepatitis or other infectious diseases caused by unsafe aquatic products, and parasites (Howgate *et al*., 1997). For example, as mercury accumulates with time, aquaculture products tend to be safer from methyl mercury contamination than wild products because aquaculture products (especially crustaceans) are harvested at a young stage (Howgate *et al*., 1997).

However, the control of the production process in aquaculture can also have negative impacts on food quality and safety (Howgate *et al*., 1997; FAO/NACA/WHO, 1999). Insufficient and/or low-quality feed ingredients can negatively affect the taste and nutrition of aquaculture products. Use of agrochemicals such as fertilizers, pesticides, disinfectants, antibiotics, parasiticides as well as additives and other chemicals used in processing can cause chemical and biological hazards (GESAMP, 1991). Irresponsible farming practices such as excessive intensity can result in low quality water environment and, hence, low quality aquaculture products. An example is the case of off-flavour in catfish ponds in Alabama and Mississippi. High feeding rates were one of the causes of the sewage, stale, rancid, metallic, moldy, petroleum and weed tastes which were detected in channel catfish (Brown and Boyd, 1982; Lovell, 1983; Armstrong, Boyd and Lovell, 1986). Fortunately, off-flavour containment techniques are known (Boyd, 1990).

2.10 Impacts on food access

Food access means “access by households and individuals to adequate resources to acquire appropriate foods for a nutritious diet” (USAID, 1995; USDA, 1996).

High food prices are usually caused by food shortage (Timmer, 1997; Haddad, 2000). By supplying fish and other products, aquaculture can positively affect food access by lowering the prices of seafood and hence making them more affordable to consumers. Through its contribution to employment and income generation as discussed above, aquaculture can also positively affect food access by providing or improving households’ purchasing power.

However, in some instance aquaculture may reduce supplies of captured fish favoured by the poor. For example, wild stocks previously for human consumption may be used for feed production; natural resources previously for production of affordable herbivorous species (e.g. carps and tilapias) may be used to produce more expensive species (e.g. shrimps and salmons).

Besides affordability, food access is also “a function of the physical environment, social environment and policy environment, which determines how *effectively* households are able to utilize their resources to meet their food security objectives.” (Riely *et al*., 1999). Therefore, aquaculture’s contribution to food access can also come from its contribution to infrastructures and services, education and training, community forming, and tax revenues.

It can, on the other hand, also be argued that by negatively affecting other food supply sources and other industries as discussed in the previous sections, aquaculture can negatively affect food access.

2.11 Impacts on food stability

Many exogenous factors such as natural disasters, diseases, food price shocks in domestic or world markets can affect the stability of local food supply. Through providing diversified aquatic products, aquaculture can increase the stability of domestic food supplies and hence increase the country’s resistance to transitory shocks that have negative impacts on food security. In addition, stable commercial aquaculture production will help secure the incomes and jobs of its employees and hence increase the resistance of their households against transitory food insecurity.

A detailed discussion on aquaculture’s positive contribution to food security can be found in our report on “Commercial aquaculture and economic growth, poverty alleviation and food security: an assessment framework” (Cai, Leung and Hishamunda, in press).

2.12 Impacts on human health

Through providing affordable sources of good quality protein and other nutrients discussed above, and by providing incomes to households for the purchase of goods and services which they could not otherwise afford, aquaculture can have positive impacts on human health.

However, if not properly addressed, aquaculture food safety issues discussed above can negatively affect human health (GESAMP, 1991).

Aquaculture can also have negative impacts on human health indirectly. For example, increase in land salinity due to aquaculture development can reduce agricultural yields. A reduced supply of agricultural food supply can negatively affect farmers' nutrition intakes and make them susceptible to infectious diseases (MA, 2003).

2.13 Impacts on education and training

The positive contribution of aquaculture to employment and income generation will have positive impacts on education. Training provided by aquaculture farms and related businesses improves human capital. For example, the Aqualma Company in Madagascar trained biologists specializing in shrimp aquaculture and provided training to its laboratory personnel. Besides, workers in the company also received on-the-job training from participating in regular sessions to learn about proper health and occupational practices (Karmokolias, 1997).

2.14 Population and demography

Outmigration can lead to depopulation. The later tends to disrupt social services such as firefighting, and cause collapse of social networks (Tonts, Campbell and Black, 2001). Aquaculture can contribute to reversing this situation.

On the one hand, local business and employment opportunities generated through aquaculture development can help alleviate the problem of depopulation by keeping the local work force from migrating elsewhere (NACA, 1994). On the other hand, employment and business opportunities created through aquaculture development can lead to immigration of labour. In Mahajanga (Madagascar), the shrimp farming company Aqualma's employment multiplier effect has led to the creation of a village with 3 000 people in 1996 and is expected to grow to 5 000 within a year or two (Karmokolias, 1997).

However, influx of labour can be a cause of social conflicts when the chronic social-economic changes caused by it reach a threshold (Rijsberman, 1999; Lewins, 2006).

Employment opportunities provided by aquaculture related activities can positively change the gender ratio of the work force. For example, aquaculture processing plants may have a relatively high percentage of female in their work forces. In Bangladesh, women are actively involved in the shrimp industry; it is estimated that more than 50 percent of workers in the shrimp depots and processing plants are women. The scene of women collecting shrimp fry in knee to shoulder-deep water is a familiar sight in the coastal belt area (Karim *et al.*, 2006).

2.15 Community and social order

Aquaculture can help community formation and solidification. In Madagascar, thanks to Aqualma, private retail shops and catering services have been created to serve its work force and their dependents. A clinic and other social amenities were also established in Mahajanga (Hishamunda, 2000).

While aquaculture can generate employment and incomes for some people, it can also destroy the livelihood of others through its negative impacts on other industries as discussed above. Competition between aquaculture and other activities for natural and environmental resources can also cause political tensions and disrupt the harmony of local social relationships (MA, 2003). In Thailand, there have been conflicts among shrimp farmers. There are also reports of confrontations between shrimp farmers and other non-shrimp farmers and local residents. The causes of these conflicts ranged from the discharge of effluent water into the public waterways and coastal seas, to the intrusion of saline water into rice fields and the salinization of canals (Jitsanguan, Mungin and Claithong, 1993; Jenkins *et al.*, 1999).

The benefits and costs of aquaculture development can be distributed to different groups of stakeholders (Irz *et al.*, 2007). Rapid development and commercialization of aquaculture can disrupt original social order. For example, in Southeast Asian countries such as Thailand, the traditional pattern of local labour utilizing native resources to provide fish protein to communities was replaced by a new pattern of domestic or foreign private interests utilizing native manual labour and resources to provide products to high-income urban consumers (Skladany, 1992). Sometimes large quantities of natural and environmental resources have been devoted to producing a single crop, such as shrimp, while native people's requirements for livelihood and environment remain neglected; and cases of consequent social conflicts and disruption have occurred in major shrimp farming countries such as Malaysia, the Philippines, India and Bangladesh (Barraclough and Finger-Stich, 1996).

3. METHODOLOGY

The discussion in the above is focused on describing the mechanisms and observed evidence of aquaculture's impacts. While a lot of information can already be provided by such descriptions, a step forward would necessitate the utilization of a systematic approach and framework to assess the impacts of aquaculture on community economic, social and environmental welfare to the extent that policy implications can be drawn. In this section we first review the literature on impact assessment; and then based on which develop a methodology for assessing the social-economic impacts of aquaculture.

3.1 A review of literature

In this paper we do not intend to comprehensively discuss the merits and shortcomings of impact assessment methodologies found in the literature. Instead, we will only discuss the literature necessary for developing a methodology for assessing the social-economic impacts of aquaculture.

3.1.1 Setting

ICPGSIA (2003) proposed that social-economic impact assessment should help achieve extensive understanding of local and regional settings to be affected by human actions or policies, should focus on key elements of the human environment, should identify research methods, assumptions and significance, should describe comprehensive and cumulative social impacts related to the action or policy, should ensure that any environmental justice issues are fully described and analysed, and should help establish mechanisms for evaluation and monitoring of human actions, policies or programmes.

Generally speaking, the methodology for assessing social-economic impacts includes three main components. First, a plan needs to be specified to clarify the issues, the objectives, and the process of the assessment. Second, a conceptual framework needs to be established to help the reader understand the impacts being assessed. Finally, an empirical framework needs to be established and indicators must be specified to quantify these impacts.

Plan: issues, objectives and assessment process

CSR (2002) uses a 6-step process to evaluate the social-economic impact of a project. These steps consist of identification and examination of issues and definitions of specific concerns, identification of project dimensions that may impact on the social-economic environment, identification of "public" or stakeholders susceptible to impact, determination of pathway or linkage between project dimension and specific concern, assessment of impact; and estimation of certainty of that impact.

Hambrey *et al.* (1999) proposes a three-stage impact analysis process. The first stage is impact characterization. The goal of this stage is to determine the nature (positive, negative, direct, indirect, cumulative, synergistic with other impacts), the magnitude, the extent/location (area/volume covered, distribution), the timing (during construction, operation, decommissioning, immediate, delayed, rate of change), the duration (short term, long term, intermittent, continuous), reversibility/irreversibility, the likelihood (risk, uncertainty or confidence in the prediction), and the significance (local, regional, global) of the impacts. The second stage consists of quantifying and predicting the impacts. This stage can rely on professional judgment, quantitative mathematical models, experiments and physical models, and case studies. Once the impacts are identified, quantified and predicted, the third step is to assess their significance according to established standards and criteria.

These two similar evaluation processes provide a general description of how to proceed with impact evaluations. While there may be differences in details, our development of the process of assessing the social-economic impacts of aquaculture will follow the guidance provided by these two papers.

Conceptual framework

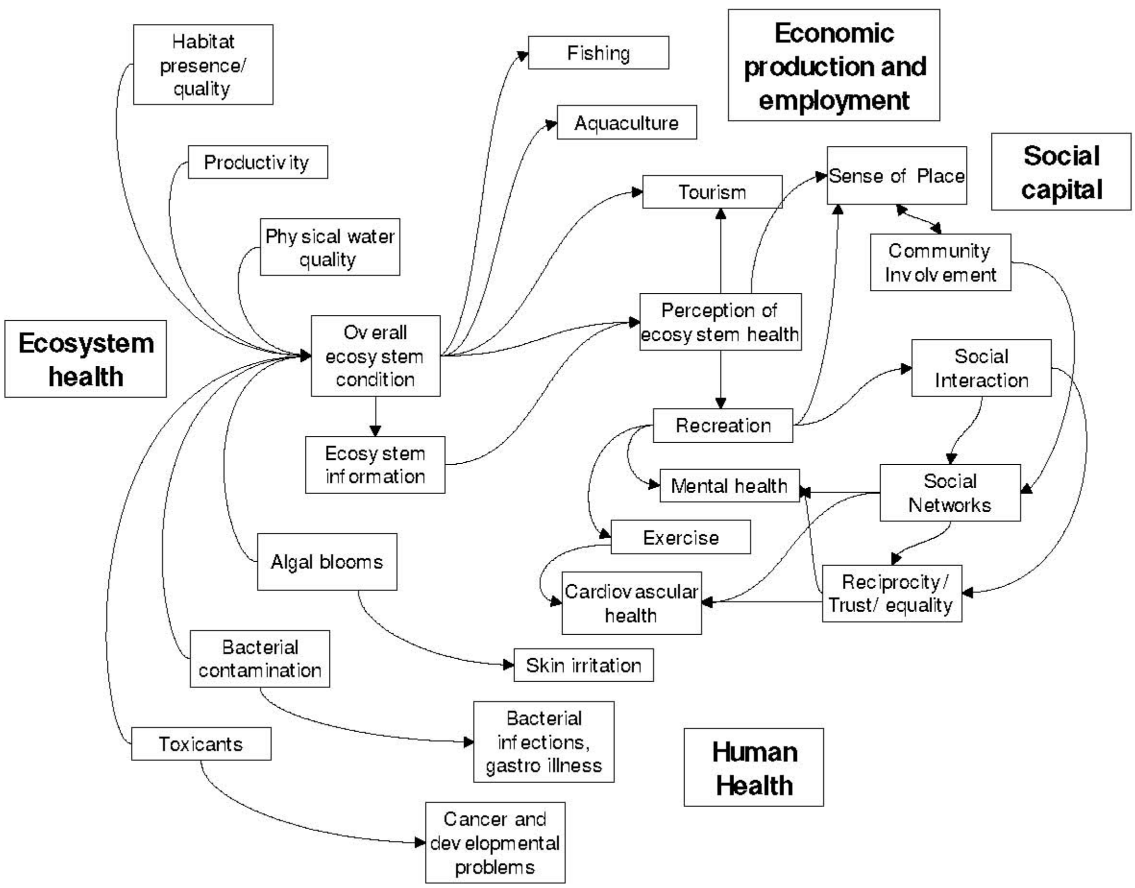
We have identified many impacts of aquaculture in Chapter II and briefly discussed the positive and negative implications of these impacts. A conceptual framework is needed to help understand the implications of these impacts to different stakeholders. A key to this framework is the concept of human social-economic well-being.

In a study of the relationships between ecosystem and human well-being, MA (2003) used the results of Narayan *et al*. (1999; 2000) to describe human well-being in 5 dimensions. These dimensions include the necessary material for a good life, health, good social relations, security, and freedom and choice. The necessary material for a good life includes secure and adequate livelihoods, income and assets, enough food at all times, shelter, furniture, clothing, and access to goods. Health encompasses being strong, feeling well, and having a healthy physical environment. Good social relations consist of social cohesion, mutual respect, good gender and family relations, and the ability to help others and provide for children. Security refers to secure access to natural and other resources, safety of persons and possessions, and living in a predictable and controllable environment with security from natural and human-made disasters. Freedom and choice imply having control over what happens and being able to achieve what a person values doing or being.

In a conceptual model that captures the impacts of ecosystem changes on human well-being, Cox, Johnstone and Robinson (2003) examined eight aspects of human well-being, including health, family and community, education and training, work, economic resources, housing, crime and justice, and culture and leisure. Cox, Johnstone and Robinson (2003) also used the concept of "social capital" to assess social well-being. According to them, social capital represents the "layer of commonly held social value, beliefs and attitudes that lie beneath individual behavior and encourages transactions that result in greater well-being for society"; the concept of social capital includes "aspects of communication, participation, networks, equality, reciprocity, cooperation and trust between resident"; and it is related to many aspects of social well-being such as "sense of place, community involvement, networks, social interaction, trust, equality, and norms of aid and reciprocity". Based on the concept of human well-being and social capital, Figure 1 describes the conceptual model used by Cox, Johnstone and Robinson (2003) to assess the effects of ecosystem health on human well-being.

In an application of the "ecological sustainable framework" to aquaculture, Fletcher *et al*. (2004) used the concept of social capital to represent the norms and networks in a society or community that enable collective action. A community with a high level of social capital usually has the following elements: high levels of trust among community members, good networks within the community, solid community networks to outside world, preparedness to help each other, high numbers of voluntary organizations, high levels of participation in voluntary organizations, effective voluntary organizations, and effective government institutions.

Figure 1. Conceptual model detailing the effects of coastal ecosystem health on aspects of human well-being (adapted from Cox, Johnstone and Robinson (2003)



Campbell (1999) used a diamond model to describe a community's five "assets", including human capital, social, natural, physical capital, and financial capital. The human capital represents elements such as the skills, knowledge, ability to work and good health, and other things that allow a person to pursue a sustainable livelihood. The social capital is the networks and relationships in communities and groups that people can utilize for their livelihoods. The natural capital is the natural resources from which benefits flow to the communities and groups. They include fish resources, land resources, water resources, etc. The physical capital includes infrastructure and tools/equipment for supporting livelihoods. The financial capital is the financial resources that people use to achieve their livelihood strategies.

Hambrey *et al*. (1999) proposed that social impacts be divided in three categories: demographic, cultural resource and socio-cultural impacts. Demographic impacts include elements such as changes in population numbers and population characteristics (such as sex ratio, age structure, in-and-out migration rates and resultant demand for social services, hospital beds, school places, housing, etc). Cultural resource impacts cover changes in archaeological, historical and cultural artifacts and structures and environmental features with religious or ritual significance. Socio-cultural impacts encompass changes in social structures, social organizations, social relationships and accompanying cultural and value systems (language, dress, religious beliefs and rituals).

The above literature provides useful guidance on how to understand the social-economic impacts of aquaculture. For example, we have discussed several environmental impacts of aquaculture in Chapter 2. Based on the many dimensions of human economic and social well-being discussed here, we then can understand how the changes in the environment may affect people's social-economic well-being and hence we can conduct a more comprehensive assessment of aquaculture's social-economic impacts.

Empirical framework

While a conceptual framework helps us understand the impacts of aquaculture qualitatively, the role of an empirical framework is to specify how to quantify them. Generally speaking, the first step is to define indicators as the measures of each impact of aquaculture; then the second step is to obtain data to quantify each indicator; and the third and final step is to utilize these indicators to assess the impacts.

Indicators

Indicators can be used to quantify the identified social-economic impacts of aquaculture so that they can be measured and compared. In the following we provide a summary of some indicators obtained in the literature.

In a case study of a shrimp farm in Northeast Brazil, Zuger (2002) classified social-economic indicators into three categories, including education, employment and wages, and family and home facilities. The education indicators include the percentage of illiteracy rate (with respect to age and gender) and years of study (with respect to age and gender). The employment indicators include unemployment rates (with respect to sector, age and gender), the type of employment and salary distribution (with respect to sector, age and gender). Their family and home facility indicators include household income, house ownership and housing facility situation, such as sanitary facilities, water-supply facilities, energy-supply facilities, etc.

In a report of planning and management for sustainable coastal aquaculture development, GESAMP (2001) used the following indicators to evaluate the social-economic impacts of cage seabass farming in Thailand: gross income per hectare, profit, return to labour (dollar per man year), employment per hectare, return to labour per hectare, employment per metric ton of product, and capital investment per job created. These indicators can be applied for comparative economic indices among different types of aquaculture.

Sanford Limited is a New Zealand company specializing in harvesting, farming, processing, storage and marketing of fisheries and aquaculture production. As a part of their commitment to sustainable seafood, the company reports the social-economic and environmental impacts of their operations.

Concerning environment, they used eco-efficiency indicators, such as electricity per kilo of product, diesel per kilo of product, coal per kilo of product, recycled lube oil as a percentage of total use of lube oil, use of fresh water per kilo of product, and quantity of solid waste (Sanford Ltd, 2006).

Community indictors include the sustainability of local fish stocks, health of the harbour and its suitability for recreational activities including fishing, and employment rates (Sanford Ltd, 2006).

Shareholder and investor indicators include financial returns, creation of shareholder value, overall sustainability of the business, and future outlook and challenges (Sanford Ltd, 2006).
Employee indicators include competitive rates of pay, working conditions and work/life balance, employee equity and benefits such as superannuation (Sanford Ltd, 2006).

Customer indicators include quality of the product, competitive pricing, steady supply, and environmental standards (Sanford Ltd, 2006).

Supplier indicators include environmental footprint (in particular waste management and packaging), customer satisfaction as well as logistics and fuel efficiency (Sanford Ltd, 2006).

For culture and tradition, the indicators include cultural value of local community and involvement of local residents in planning and management (Sanford Ltd, 2006).

In relation to the seafood industry, the indictors include property protection, access protection and aquaculture management areas (Sanford Ltd, 2006).

Government and non-governmental organization indicators include property protection and access, ocean policies, cooperation between government, NGOs and industry, ecosystem effects of the industry and environmental certification.

In an assessment of the environmental performance of European marine fisheries and aquaculture, Zenetos, Streftaris and Larsen (2002) utilized the existing literature to compile a variety of indicators regarding the impacts of fisheries and aquaculture on environment and human well-being. A summary of the indicators related to aquaculture provided in the paper is provided in Table 1.

Data

Data availability is usually a major constraint in impact assessment. An assessment framework would not be practically useful if its data requirements for data are difficult to satisfy. The literature indicates that major data sources include the literature, published or unpublished data, and interviews or surveys.

In an assessment of the social and economic implications of farm plantation forestry in Australia, Tonts, Campbell and Black (2001) first conducted a detailed review of academic papers, published and unpublished reports, policy documents, and newspaper or magazine articles to gather information on the findings of previous studies. Based on the results of the review, they designed case studies for a more detailed empirical study. They used published and unpublished data (such as statistics yearbooks and annual reports) to evaluate the economic, demographic and social profiles of the communities under study. They also used direct interviews with stakeholders (including government officials, business owners, managers and/or representatives, farmers, regional development agencies, and government agencies) for information on their attitudes, experience and perceptions of the impacts of forestry plantation. Phone surveys were used to obtain information on the attitudes, experience, and perception of local residents.

In a case study on perceptions of aquaculture by communities and stakeholders in the Port Phillip Region of Australia, Mazur *et al*. (2004) obtained empirical data from a literature review, 31 interviews with government agency staff members, aquaculture industry representatives, researchers, conservation organizations and community members, and mail surveys of 700 households.

Table 1: Indicators and measure of aquaculture's impact

Indicators	Measure of aquaculture's impact on
Aquaculture production	Fish supply
Prices of aquaculture products	Fish demand
Food quality of cultured fish	Food quality and safety
Average wage in aquaculture/average national wage	Attractiveness of aquaculture as a commercial activity
Technological improvement	Attractiveness of aquaculture as a commercial activity
Food conversion ratio	Eco-efficiency
Sales of chemicals to aquaculture	Water quality and/or land quality
Quality of effluent water	Water quality and/or land quality
Concentration of harmful chemical residues in areas of intensive aquaculture activity compared to other areas	Water quality and/or land quality
Aquaculture's use of food stuff of marine origin	Wild populations
Supply of fry	Wild populations
Number of escapees per km coast/ha inland water	Wild populations
Frequency of farmed genotypes in wild populations	Wild populations
Disease frequency in wild populations of farmed species	Wild populations
Disease incidence	Wild populations and social-economic stability
Biodiversity near aquaculture sites compared to other areas	Ecosystem

Adapted from Zenetos and Larsen (2002) with modification

Assessment

While indicators can be used as separate measures of the multiple dimensions of aquaculture's social-economic impacts on different stakeholders, we also need to assess each stakeholder group's tradeoffs among these multiple dimensions; and we also need to assess, from the perspective of the entire society, the tradeoffs among different stakeholder groups.

Cost-benefit analysis

Cost-benefit analysis (CBA) is an often-used method to assess the tradeoffs among multiple impacts. Aquaculture tends to have both positive and negative impacts on stakeholders. Aquaculture's positive impacts on individual stakeholders are its benefits to them; and its negative impacts on them are its costs. The aggregation of the positive impacts on all the stakeholders is aquaculture's total benefit to the society; and the aggregation of all of its negative impacts is its total cost. CBA is a method to synthesize the positive impacts (benefits) and negative impacts (costs) to estimate the net impact.

Conceptually, CBA is based on the Kaldor-Hicks "compensation principle". For individual stakeholders, the compensation principle implies that the benefits provided by a programme (e.g. aquaculture) can be used to compensate the costs caused by it. That is, as long as the net impact of aquaculture on a stakeholder is positive, we can say that aquaculture improves the well-being of this stakeholder. For the society as a whole, the compensation principle implies that the benefits on individual stakeholders can be used to compensate the costs of other stakeholders. That is, as long as the net impact of aquaculture on the entire society is positive, we can say that aquaculture improves the social welfare.

In order to be able to aggregate the benefits and costs into the net impact, CBA uses monetary units to measure benefits and costs. This makes CBA an appealing approach in that a monetary measure of the net impact appears more understandable and convincing in political discourses. However, while the monetary values of some variables such as aquaculture products can be determined directly by their market value, the monetary values of non-market resources (e.g. mangrove forests) or externalities (e.g., pollution) need to be estimated. The monetary values of non-market resources can be estimated by their "opportunity costs". For example, the value of mangrove forests used for shrimp farming can be measured by the benefits provided by these forests if they are used for other purposes (Cruz-Trinidad, 1994). The monetary values of negative externalities can be measured by the costs needed to correct them.

Another difficulty in implementing CBA is to determine the monetary values of non-economic variables such as clean water, safe neighborhood, the sense of place, etc. The monetary values of such variables are usually measured indirectly by stakeholders' revealed preferences. For example, the value of beautiful scenery to tourists can be measured by their travel costs incurred to enjoy it. Here the travel costs are used as surrogate prices to reveal tourists preferences over the scenery. Similarly, the value of a safe neighbourhood can be measured by the estimated housing price premiums caused by this special characteristic.

When surrogate prices are not available to reveal stakeholders' preferences, the contingent valuation approach can be used to obtain information about stakeholders' stated preferences. In short, the contingent valuation approach measures individuals' preferences by their stated "willingness to pay" (WTP) for social or environmental amenities or "willingness to accept" (WTA) compensation for social or environmental disutility (McFadden, 1994; Baker and Pierce, 1997; Gunawardena and Rowan, 2005). To apply the contingent valuation approach in practice, surveys containing questions such as "How much would you be willing to pay for an additional unit of good X" or "How much compensation would you demand so as to be willing to bear with an additional unit of bad Y" need to be designed and conducted to extract people's WTP or WTA.

<u>Multiple criteria decision-making or multiple attributes decision-making</u>

By measuring the benefits and costs of aquaculture by common monetary units, CBA can assess the tradeoffs among the multiple dimensions of impacts on different stakeholders. However, when impacts are incommensurable, CBA would be invalid; and the multiple criteria decision-making (MCDM) or multi-attributes decision-making (MADM) methods need to be used.

Unlike CBA, MCDM/MADM usually does not rely on a single metric to measure the positive and negative impacts of a program. Instead, MCDM/MADM explicitly introduces the multiple dimensions of the impacts and evaluates each stakeholder's tradeoffs among the multiple impact dimensions and the tradeoffs among different stakeholders under each impact dimension.

The multiple attribute utility theory (MAUT) is a MADM most similar to CBA. Unlike CBA, MAUT does not use a monetary unit to measure the benefits and costs, but it uses attribute utility functions to estimate the utility of the benefits and the disutility of the costs to stakeholders. Using estimated weights, these utility and disutility can be aggregated to derive the net utility as a measure of the net impact of a programme.

Conceptually, the MAUT approach categorizes impacts into different dimensions (or aspects) such as economic, social, environmental dimensions. Each dimension contains multiple attributes (e.g., productivity and profitability for the economic dimension, food security and food safety for the social dimension, and land quality and water quality for the environmental dimension). Practically, the MAUT approach first estimates attribute utility functions based on stakeholders' revealed preferences, and then estimates the attribute weights so that stakeholders' utility or disutility from different attributes can be aggregated. To aggregate the impacts from all the dimensions on a stakeholder, the MAUT approach also needs to estimate weights that measure the tradeoffs among the dimensions.

Finally, the MAUT approach can aggregate the impacts for all the stakeholders through certain aggregating procedures using estimated society weights (van Calker *et al*., 2006).

Analytical hierarchy process (AHP) is another popular MADM method. Developed by Thomas Saaty and his colleagues, the analytical hierarchy process (AHP) method is one of the most widely used multiple criteria decision-making methods (Saaty, 1990a; Saaty and Vargas, 1994).

Unlike MAUT, AHP does not attempt to specify utility functions to describe stakeholders' preferences. Instead, AHP use a series of pair-wise comparisons to elicit stakeholders' preferences. When a decision needs to be made based on multiple criteria, the AHP method would first conduct pair-wise comparisons between every two criteria and use the eigenvalue method to determine the relative weights of these criteria. These weights measure the relative importance of the criteria; the larger is the weight for a criterion, the more important is this criterion.

The second step is to conduct pair-wise comparisons between every two options under each criterion and again use the eigenvalue method to determine the relative weights for all the options. These weights measure the relative preference of each option under a specific criterion; the larger is the weight for an option, the more preferred it is under the criterion.

As the relative weights for all the criteria and the relative weights for all the options are derived, the final step of the AHP method is to aggregate these relative weights to arrive at a set of ratings for the alternative options. The option with the highest rating would be the one that is most preferred.

AHP is a very powerful tool in that a similar analytical process can be applied not only to a group of criteria but also to the sub-criteria of each of these criteria, the sub-criteria of each of the sub-criteria, and so on.

In addition to MAUT and AHP, other MCDM methods include weighted linear combination (WLC), analytical network process (ANP), and the order weighted average (OWA) method (Kapetsky and Aguilar-Manjarrez, 2007).

Cost-benefit analysis vs multiple criteria decision-making

One main advantage of CBA is its use of market value to measure benefits and costs, which provides a more objective foundation for social choices (Munda 1996). In political discourses it is always advantageous to be able to provide a quantitative measure that can be easily understood by the public or at least make them think they understand.

However, CBA is essentially an impact-oriented approach whose main goal is to derive the net impact without paying much attention to the bearers of the positive and negative impacts being aggregated. For example, when we use CBA to compare the benefits provided by aquaculture to the costs of its detrimental impacts on the environment, we are to a certain extent considering the tradeoffs between aquaculture's positive impacts on current generations and its negative impacts on future generations. If the comparison shows that the benefits are greater than the costs, we may say that the CBA result indicates that aquaculture "improves" the social welfare. But it should be noted that the benefits enjoyed by the current generations are at the costs of future generations; and the positive net impact only indicates that under certain welfare criteria, the benefits are deemed prevailing the costs.

Therefore, while CBA is a useful method to assess the efficiency of resource utilization for given stakeholders, its application to the assessment of the net social impact tends to be controversial, especially when the distributional impacts need to be taken into consideration (Spash and Vatn, 2006).

Another problem is whether the estimated monetary values of cultural, environmental and other non-economic variables are reliable. As stakeholders may have no experience of directly paying for social or environmental amenities, it is not unusual for them to feel difficult to determine a monetary measure of their WTP (Prato, 1999). As people's willingness to pay is usually positively correlated with their ability to pay, the WTP measures would tend to assign higher value to variables preferred by richer people (Munda, 1996). When respondents realize that their stated WTP would be used in policy decision process to value certain impacts, they have incentives to overstate their WTP for the impacts they desire and understate their WTP for those they dislike (Munda, 1996). Given all these, it should not be surprised to find large divergence of WTP or WTA measures among different respondents (Spash and Vatn, 2006).

Compared to CBA, MCDM methods are more stakeholder-oriented. Indeed, while CBA focuses on the net impact and only attempts to make trade-offs between the dimensions of the problem explicit within its sensitivity analyses, MCDM/MADM methods treat tradeoffs among different stakeholders and criteria as a focus of attention (Joubert *et al.*, 1997).

Unlike CBA, MCDM methods do not require to use a single metric to measure multiple impacts. This on the one hand makes the information provided by MCDM methods less definite, but on the other hand makes the information richer. As MCDM methods explicitly assess the positive and negative impacts under multiple criteria, they can provide insights about the nature of various tradeoffs and hence guidance about how to reach compromises among conflicting interests (Martinez-Alier *et al.*, 1998). In addition, free from assigning monetary values to non-market variables, MCDM can avoid some problems of CBA such as low quality of WTP or WTA measures (Prato, 1999).

While CBA tends to be a top-down evaluation technique, MCDM is a community-based decision making process (Prato and Herath, 2007; Joubert *et al*., 1997). Under CBA, government agencies determine the information needed to be gathered for the assessment, but there are often few guidelines for government bureaucrats to determine what information is needed. Consequently, CBA tends to become a very detailed, extensive, expensive, and time consuming process with a large amount of information gathered being irrelevant to the final decision (Joubert *et al*., 1997). In contrast, MCDM methods are bottom-up evaluation procedures designed to guide stakeholders to examine their tradeoffs among multiple impacts under different criteria. The participatory nature of MCDM methods can also keep policymakers informed about the tradeoffs of each policy alternative (Joubert *et al.*, 1997).

We have introduced in the above MAUT and AHP as two MADM methods. Both methods do not require measuring impacts in monetary value. AHP offers a straightforward and standardized way for making complex decisions and keeps the decision making process transparent and objective (Parra-Lopez *et al*., 2007). In contrast, the need for specifying attribute utility functions make AUT more complicated and require more subjective judgments.

Practically, AHP is more user friendly because of the availability of programs such as expert choice software (Parra-López and Calatrava-Requena, 2006). AHP has been applied in research on fisheries and aquaculture management. For example, Leung et al. (1998) used the AHP method to evaluate fisheries management options in Hawaii. Soma (2002) used the method to evaluate fisheries management options for sustainable fisheries development in Trinidad and Tobago. Mardle and Pascoe (2003) used the AHP method to elicit weights of the various fisheries objectives to be employed in a goal programming model of the several EU fisheries. Mardle, Pascoe and Herrero (2004) used the AHP method with a pair-wise comparison survey to develop weights to measure the importance of groups within the management process in a study of the UK fisheries of the English Channel that sought to investigate the priorities among the various diverse groups on the management process. Wattage and Mardle (2005) used the AHP method to quantify stakeholder preferences for conservation of wetlands versus conversion for development in Sri Lanka. Nielsen and Mathiesen (2006) used the AHP method to evaluate the preference of the various stakeholders for management of sand eel and Norway pout fisheries.

3.2 A suggested methodology for assessing the social framework: stakeholder approach

Based on the impacts identified and the methodologies discussed in the above, we will develop a methodology for the assessment of aquaculture's social-economic impacts in this section. The methodology is essentially a process of data collection and information extraction. We will try to make clear the information we need, then find a way to acquire the information, and then discuss on how to use the information.

The methodology consists of three levels. The first level is to use indicators to measure aquaculture's positive and negative impacts. These indicators provide basic information about aquaculture's impacts. The second level is to link the impacts to stakeholders' social-economic well-beings. The third level is to comprehensively assess the tradeoffs among the multiple dimensions.

3.2.1 The conceptual framework

Conceptually, we call the methodology a "stakeholder approach", which includes four steps. The first step is to identify stakeholders who tend to be influenced by aquaculture. The second step is to identify the factors through which aquaculture affects the stakeholders' well-beings. The third step is to clarify how these factors affect the stakeholders' social-economic well-beings. The fourth step is to use CBA and/or MADM methods to assess the tradeoffs of these welfare impacts.

Stakeholders

The stakeholder is any person or organisation who can be positively or negatively impacted by, or cause an impact on the success of the project. A stakeholder analysis is an analysis that aims to identify and analyse the different people or groups – stakeholders – that are affected by the results of the project. A stakeholder analysis is performed when there is a need to clarify the consequences of envisaged changes or at the start of new projects and in connection with organizational changes generally.

One key element of assessing the social-economic impacts of aquaculture is to identify stakeholders related to aquaculture. The stakeholders must be human beings or representatives of human beings, for example companies, governments or NGOs. Animal welfare may be an aspect of social and economic impacts of aquaculture. However, the stakeholders with respect to animal welfare are not animals *per se*, but people who care about animal welfare.

The focus on the utility of human beings would lay down a basis for the assessment of social and economic impacts of aquaculture. Most of the impact assessments in the literature take into consideration the welfare of stakeholders, but oftentimes stakeholders' welfare is treated as one of aquaculture's many impacts (e.g. Hambrey *et al*., 1999). This is convenient when the purpose is to identify aquaculture's many impacts like we did above. However, when the purpose is to assess these impacts, the focal point would be the implications of aquaculture's impacts on stakeholders' well-being.

Stakeholders in aquaculture can be classified in six main categories: those engaging in aquaculture production chain activities, those engaging in support industries, those engaging in competing industries for natural and/or environmental resources, those engaging in the use of aquaculture products, and those severely concerned with the impacts of aquaculture, and those stakeholders in the future.

Stakeholders engaging in aquaculture production chain activities include seed producers (including hatchery/nursery workers and fry collectors), fish farmers, fish traders (including exporters), merchants and fish processors, among others.

Stakeholders related to industries in support of aquaculture consist of feed producers, fertilizer producers, equipment manufacturers, constructors for farm building, and transporters, among others.

Stakeholders engaged in activities that compete with aquaculture for natural and/or environment resources comprise fishers, agricultural farmers, tourism companies, tourists and local residents, among others.

Stakeholders related to activities that use aquaculture products include local households, foreign countries, restaurants and pharmaceutical companies, among others.

Stakeholders that are severely concerned about the impacts of aquaculture include especially advocacy groups such as conservation groups, among others.

Stakeholders in the future can be represented by farmers associations, governments and development agencies, among others.

The above stakeholders can be further disaggregated. For example, a commercial fish farm can include workers and shareholders as two different stakeholders.

Factors

Based on the discussion in Chapter 2, factors through which aquaculture can affect stakeholders' social-economic well-being include incomes, employment, supply of food, infrastructures and social services, education and training, population and demography, health, leisure, family relation, social interactions, social order, land, water and other natural and environmental resources, among others.

Aquaculture can affect a stakeholder's well-being through many factors. For example, by allowing a seed producer to acquire clothing (material consumption), incomes from aquaculture can be a factor by which aquaculture affects this stakeholder's utility from material consumption dimension. By brushing with water contaminated through aquaculture, the seed producer's well-being may well be negatively affected. Thus, contaminated water due to aquaculture can be a factor by which aquaculture affects the seed producer's utility from the physical environment dimension.

Aquaculture can also affect many dimensions of stakeholders' well-being through one factor. Water pollution caused by aquaculture can affect not only the seed producer's utility from the physical environment as discussed above, but, it can also affect his utility from material consumption. An example can be when he consumes the fish grown in polluted water; polluted water can negatively affect the quality of aquatic products. Employment opportunities provided by aquaculture can provide stakeholders not only with spiritual utility from a sense of self-fulfillment, but they can also provide utility from a benign social environment because of low crime rates; experts generally agree that there is a negative relationship between employment and crime rate, or a cause-and-effect relationship between improvements in the labor market and lower rates of crime (US Department of Justice, 1997; Bernstein and Houston, 2000).

The main product of the first and second steps is Table 2, which presents the stakeholders and factors in a matrix form. The main empirical task in the second step is to use indicators to describe how aquaculture affects the stakeholders through the factors. It should be noted there could be multiple indicators in each cell of Table 2. For example, we may use the average wage rate in aquaculture to measure one benefit provided by aquaculture to its workers. We may use the ratio between aquaculture's wage rate and the average wage rate in the entire agriculture sector as an indicator to show whether aquaculture provides higher or lower pay jobs than other agricultural activities. We may also use the ratio between aquaculture's wage rate and the average wage rate in the entire economy as an indicator.

The indicators here are not intended to be used to conduct welfare analysis. Instead, they would be used to capture the various impacts of aquaculture on each stakeholder through each factor. We would attempt to construct as many indicators as possible so as to provide a comprehensive picture about the impacts of aquaculture on the stakeholders.

We believe that the impact assessment in this step is what many impact assessments in the literature try to achieve. Although this level of impact assessment does not directly show the welfare impacts of aquaculture, it provides a lot of useful information in policy decision making process. Moreover, the information would also lay down a foundation for the welfare analysis in the next two steps.

Table 2: Source of aquaculture impacts on stakeholders

Source of impacts	**Stakeholder 1**	…	**Stakeholder *n***
Economic factors		…	
Incomes		…	
Social factors		…	
Employment		…	
Supply of food		…	
Infrastructure and social services		…	
Education and training		…	
Population and demography		…	
Social order		…	
Health		…	
Leisure		…	
Family relations		…	
Social interactions		…	
Environmental factors		…	
Land		…	
Water		…	
Wild stocks		…	
Other natural and environmental resources		…	

Impacts on stakeholders' well-beings

The purpose in the third step is to specify how aquaculture affects the welfare of each stakeholder through each factor. The task here is also to fill in the many cells in Table 2. However, while we pursue a comprehensive description of aquaculture's impacts in the second step, the purpose here is focused on the impacts on stakeholders' well-being.

To assess aquaculture's impacts on stakeholders' well-being, we need to specify alternative scenarios for comparison. For example, suppose the size of the aquaculture sector increases, then we need to specify how the natural resource requirements for the expansion (e.g. mangrove destruction) affect each shareholder; we need to specify how the human resource requirement for the expansion affects the demography structure of the community and the welfare implications of this impact; and so on.

It should be noted that we do not require the welfare measures in Table 2 to be in the same unit. For example, the welfare measure for the income impact can be in a monetary unit, while the measure for the employment impact can be 1 (if employed) and 0 (if unemployed). Of course, it would be more desirable if all the welfare measures can be in the same metric, but we do not need to force the issue.

We would already obtain plenty information even with no common metric. At the least, we would know how aquaculture affects stakeholders' well-being through each factor. As the welfare measure for the same factor tends to be in the same metric (e.g. the income impacts on all the stakeholders would tend to be measured by the same monetary unit), we can assess the tradeoffs among different stakeholders with respect to each factor; and we can also assess the net welfare impact with respect to each factor. For example, we can see which stakeholders increase their incomes by aquaculture expansion and which stakeholders have their incomes reduced; and we can also estimate the net income impact for all the stakeholders by using CBA.

The net impact on stakeholders' well-being

A natural step following the third step is to assess aquaculture's net impact on each stakeholder's well-being and its net impact on the social well-being. To achieve this goal, the tasks in the fourth step include aggregating aquaculture's impacts on each stakeholder through all the factors and then aggregating each stakeholder's net impact into the net social impact.

3.2.2 The empirical framework

With the conceptual framework laid down in the last section, we need an empirical framework to specify how to practically conduct the impact assessment. The empirical framework would need to specify what data are needed, how to obtain them, how to extract information from them, and how to interpret the information.

For the first two steps where we need to identify stakeholders and specify indicators to describe aquaculture's impacts on them through various factors, we expect to obtain data mainly from the existing literature as well as expert opinions. Of course, survey data, if available, would also be used here to construct indicators.

For the third step where we need to measure aquaculture's impacts on each stakeholder through each factor by comparing alternative scenarios, some data (e.g. income and employment data) may be available from public sources, while some data (e.g. aquaculture's impact on its workers' health) may need to rely on surveys.

The empirical procedure here would be to obtain as much information as possible from the existing literature and then use surveys to obtain data not readily available. These surveys need to be well planned in advance because the design of a survey on one stakeholder may require information from the survey on another stakeholder. For example, a foreseeable difficulty in such surveys is that it may not be possible to clearly specify the alternative scenarios before the survey. For example, to survey upon aquaculture's impacts on tourists, we would probably need information about aquaculture's impacts on social order (e.g. crime rates) so that tourists can properly evaluate their well-being under alternative situations.

For the fourth step where the multiple welfare impacts need to be aggregated into the net impacts, the main empirical issue is which methods to adopt for the aggregation.

As the welfare measures specified in the third step are not necessarily in a common unit, it may not be feasible to apply CBA to assess the net impacts on individual stakeholders or the net social impact.

CBA would be useful if we want to evaluate the tradeoffs among those variables in the same unit. But there exists a difficulty because of the fact that different aspects of stakeholders' well-being tend to interact with one another. For example, as healthier people would have more utility from the same amount of consumption than those in a poor health state, the same amount of income would provide different utility to the same stakeholder in different health states. Thus, even if we can obtain a monetary measure of health, strictly speaking, we still cannot use CBA to assess the tradeoffs between income and health if the interactions between them are not insignificant.

If we want to include all the individual impacts in the assessment of the net impact, MADM methods need to be used. As discussed in the above, we suggest using AHP.

As the use of AHP in social-economic impact assessment is not yet a standard practice, we explain in detail the procedure in the next section.

3.2.3 The AHP method

AHP is usually used to aid the decision making process by providing a systematic framework to compare alternatives under different criteria. It should be noted that AHP is not merely the process of aggregating impacts. It is not that we first estimate aquaculture's impact on each shareholder through each factor and then use AHP to aggregate them to derive the net impacts. Actually, AHP is also a process to measure those individual impacts. In other words, compared to the conventional CBA using monetary units to measure benefits and costs, AHP is also a variant of cost-benefit analysis that uses priority index as the common unit to measure benefits and costs (Saaty, 2000, Chapters 12 and 13).

In the following we use an example to illustrate the key points in the application of AHP in the assessment of aquaculture's social-economic impacts. Suppose through the first three steps we obtain Table 3, which shows the situations in the benchmark scenario vs. the alternative scenario. The first two columns in Table 3 compare the situation of aquaculture producers under the benchmark scenario with aquaculture to their situation under the alternative scenario without aquaculture. In this hypothetical example, we assume for simplicity that without aquaculture, aquaculture producers' incomes would be reduced to zero; they would lose their jobs as well as the education and training provided by the jobs; their consumption of aquatic products would be reduced by 30 percent; the road built by the aquaculture company would not be there; there would be no aquaculture-induced immigrants; there would be no aquaculture-induced conflicts; and the mangroves destroyed for aquaculture would still be kept intact.

The last two columns compare the benchmark and alternative scenarios for local residents. We can see that the situation for the "general factors" is the same as that for aquaculture producers, while the situation for the "individual factors" is different.

Note that the benchmark and alternative scenarios for the "intangible factors" are not specified in Table 3; and we will see that the AHP method would help provide measures to them.

After the benchmark and alternative scenarios are specified, we can continue to use the AHP method to compare stakeholders' well-being under the different scenarios.

The first step is to ask each stakeholder to pair-wise compare the factors in first column in Table 3 and use the results to derive their relative weights for the factors. For each stakeholder, the total relative weights for all the factors would be equal to one; and a larger weight for a factor implies that the factor is relatively more important to the stakeholder than other factors. For example, suppose the relative weights for incomes and health of the aquaculture producer in Table 3 are 0.56 and 0.30 respectively, then it would mean that this producer weighs incomes as a factor affecting his well-being more important than health.

The second step is to ask each stakeholder to pairwise compare the benchmark and alternative scenarios for each individual factor and use the results to derive their relative weights for the scenarios. For each factor, the total relative weights for all the scenarios would be equal to one; and a larger weight for a scenario would imply that as far as that factor is concerned, the stakeholder is relatively more preferred this scenario. For example, suppose for the factor of social order, the aquaculture producer's relative weights for the scenario with aquaculture and that without are 0.4 and 0.6 respectively; then it would mean that as far as social order is concerned, the aquaculture producer prefers the scenario without aquaculture further than that with.

Table 3: Impacts of aquaculture on producers and local residents

Impacts from the following factors	Aquaculture producers		Local residents	
	Benchmark: with aquaculture	**Alternative: without aquaculture**	**Benchmark: with aquaculture**	**Alternative: without aquaculture**
Individual factors				
Incomes	Current wages	zero	Current wages	Current wages
Employment	Yes	No	Yes	Yes
Education and training	Current situation	No	No	No
General factors				
Prices of aquatic products	Current level	30% higher	Current level	30% higher
Infrastructure and social services	Road	No road	Road	No road
Population and demography	Immigrants	No immigrants	Immigrants	No immigrants
Social order	Conflicts	No conflicts	Conflicts	No conflicts
Ecosystem	Mangroves destroyed	Mangroves intact	Mangroves destroyed	Mangroves intact
Intangible factors				
Health				
Leisure				
Family relations				
Social interactions				

After the pair-wise comparisons in the second step, the cells in Table 3 would all be filled with relative weights, even for those intangible factors (i.e. health, leisure, family relations and social interactions) that are not specified in the first place. This is because given the specified benchmark and alternative scenarios and their own situations, stakeholders would be able to make judgments about their preferences over the different scenarios regarding these factors. In other words, the relative weights are the cost and benefit measures estimated by AHP.

When the relative weights for measuring the relative importance of each factor and the weights for measuring the relative preference over each scenario are derived, the last step would only involve simple aggregation. Let $\alpha_{i,j}$ denote the relative weight of stakeholder i for factor j and $\beta_{i,j,k}$ denote stakeholder i's relative weight for scenario k with respect to the factor j; then the relative well-being of stakeholder i in scenario k can be measured by $\Pi_k = \sum_j \alpha_{i,j} \beta_{i,j,k}$. The greater the Π_k is, the higher well-being the stakeholder has in scenario k. Thus, if a stakeholder's Π under the scenario "with aquaculture" is greater than Π under the alternative scenario (without aquaculture), we can conclude that aquaculture has improved this stakeholder's well-being.

There tends to be many individuals in each stakeholder group; and individuals in the same group may not have the same preferences. Therefore, we need to derive a measure of the group well-being based on the well-being measures of individuals in the same group. Saaty (2000) suggests using the geometric means of individuals' priority scores to represent the priority scores for the entire group. An ideal situation would be to apply the AHP method to all the individual stakeholders in a group and calculate the geometric means of their priority scores. When it is not feasible to include all the individual stakeholders in a group, a certain number of representative stakeholders in the group should be selected for the AHP assessment; and the geometric means of their priority scores can be used to represent the group's priority scores.

After the AHP assessment of aquaculture’s impacts on the well-being of each stakeholder group, the final step would be to further derive its impact on the well-being of the entire society. For that, the relative weights for measuring the significance of the well-being of each group need to be determined. Technically, the AHP method can handle this task similar to the way it is used to derive a stakeholder’s relative weights for different welfare dimensions. However, in practice, who should be the social planner to determine the relative significance of the welfare of different stakeholder groups that tend to differ in many dimensions such as size and economic condition?

One method is to let policymakers who conduct the assessment to determine the relative weights for the stakeholder groups under evaluation according to the purpose of the assessment. Another perhaps more objective method is to use the AHP method to let all the stakeholders under evaluation to determine the relative significance of their welfare. We can first ask each stakeholder to pair-wise compare the significance of the welfare of all the stakeholder groups under evaluation. Each stakeholder perhaps would rank the significance of the welfare of his/her own group the highest, but at the same time he/she would also provide the significance rankings for other stakeholder groups. Then we can calculate the geometric mean of all the significance rankings and use the mean to determine the relative significance of the welfare of each stakeholder group.

4. APPLICATION OF THE SUGGESTED METHODOLOGY

This chapter uses illustrative examples to show how to apply the methodology developed in the previous chapter to assess the social-economic impacts of aquaculture.

In sum, the methodology that we develop in the above for assessing aquaculture’s social-economic impacts include 4 steps: 1) identifying stakeholders and factors through which aquaculture affects the stakeholders and specify indicators to measure these impacts; 2) specifying stakeholders’ well-being, identifying factors that affect stakeholders’ well-being, defining indicators to measure these factors; 3) specifying alternative scenarios to assess how aquaculture affects each stakeholder’s well-being through each factor; and 4) applying the AHP method to measure the well-being impacts in the last step in commensurable relative weights and aggregate these weights to estimate aquaculture’s net impact on each stakeholder and its net impact on the well-being of the society as a whole.

The above discussion should have provided sufficient guidance to conduct the first three steps, which tend to be case specific and have no ready-made formula to follow.

From the first two steps, we would be able to construct a table which is a filled in version of Table 2.

From the third step a table representing including all the stakeholders and factors identified in the first two steps would be produced.

As the last step is relatively new to the assessment of aquaculture’s social-economic impacts and relatively more complicated, we would provide an illustrative example in the following.

For simplicity, in Table 4, we consider only 8 factors and a shrimp farmer as one stakeholder. The task here is to assess the impact of shrimp farming on shrimp farmer’s socio-economic well-being.

The first step is to interview the farmers to obtain their relative weights for each of the 8 factors shown in Table 4. For this, we need a scale system to guide the farmer to conduct pair-wise comparisons. This scale is provided in Table 5. Note that the scale system is reciprocal. That is, if the scale of factor “i” is “m” when compared to factor “j”, then the scale for factor “j” would be 1/m.

The results of the pair-wise comparisons based on the scale system in Table 5 are reported in Table 6. From Table 6 we can see that the shrimp farmer deems factor 1 (income) more important than most of the other factors except factor 3 (health), factor 7 (social order) and 8 (ecosystem). Factor 4 (family relation) is also less important than all the other factors and factor 8 (ecosystem) more important than all the other factors.

Table 4: Impact of shrimp farming on farmer's socio-economic well-being

Factor No.	Impacts from the following factors	A shrimp farmer
1	Incomes	
2	Employment	
3	Health	
4	Family relations	
5	Social interactions	
6	Infrastructure and social services	
7	Social order	
8	Ecosystem	
Net impacts		

Table 5: Scale system for pair-wise comparisons

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two factors contribute equally to the well-being
3	Moderate importance of one over another	Experience and judgment strongly favour one factor over another
5	Essential or strong importance	Experience and judgment strongly favour one factor over another
7	Very strong importance	A factor is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one factor over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	

Adapted from Saaty (1990b) with modification

Table 6: Results of general pair-wise comparisons

Factor No.	1	2	3	4	5	6	7	8	Priority vector
1	1	5	3	7	6	6	1/3	1/4	0.173
2	1/5	1	1/3	5	3	3	1/5	1/7	0.054
3	1/3	3	1	6	3	4	6	1/5	0.188
4	1/7	1/5	1/6	1	1/3	1/4	1/7	1/8	0.018
5	1/6	1/3	1/3	3	1	1/2	1/5	1/6	0.031
6	1/6	1/3	1/4	4	2	1	1/5	1/6	0.036
7	3	5	1/6	7	5	5	1	1/2	0.167
8	4	7	5	8	6	6	2	1	0.333

While it is easy to see from Table 6 that factor 4 is the least important factor and factor 8 is the most important one for this shrimp farmer, the overall rankings of other factors are not easy to discern by observation. Fortunately, for this kind of reciprocal matrix, the overall rankings of all the factors can be described by its principal eigenvector of the matrix, which is reported in the last column of Table 6 under the title of "priority vector". The elements in this priority vector are the shrimp farmer's relative weights for each factor, which measures their relative importance to the shrimp farmer's well-being. According to the vector, the most important factor to the shrimp farmer's well-being is factor 8 (ecosystem, 0.333), followed by factor 3 (health, 0.188), factor 1 (incomes, 0.173), factor 7 (social order, 0.167), factor 2 (employment, 0.054), factor 6 (infrastructure and services, 0.036), factor 5 (social interactions, 0.031), and the last by factor 4 (family relations, 0.018).

The second step is to ask the shrimp farmer to conduct pair-wise comparisons of the scenarios with and without aquaculture regarding each factor. The scale system used here is also Table 5; and the results are reported in Table 7.

Table 7: Results of pair-wise comparisons of the scenarios with and without aquaculture

Income	**Yes**	**No**	**Priority vector**	**Employment**	**Yes**	**No**	**Priority vector**
Yes	1	9	0.9	Yes	1	6	0.857
No	1/9	1	0.1	No	1/6	1	0.143
Health	Yes	No	Priority vector	Family relations	Yes	No	Priority vector
Yes	1	1/3	0.25	Yes	1	2	0.667
No	3	1	0.75	No	1/2	1	0.333
Social interactions	Yes	No	Priority vector	Infrastructure and service	Yes	No	Priority vector
Yes	1	5	0.833	Yes	1	5	0.833
No	1/5	1	0.167	No	1/5	1	0.167
Social order	Yes	No	Priority vector	Ecosystem	Yes	No	Priority vector
Yes	1	1/2	0.333	Yes	1	1/4	0.2
No	2	1	0.667	No	4	1	0.5

According to Table 7, as far as income, employment, family relations, social interactions, and infrastructure and services are concerned, the shrimp farm would prefer the scenario "with aquaculture", while he would prefer the scenario "without aquaculture" regarding health, social order and ecosystem.

Table 8: Relative weights of general and scenario pair-wise comparisons

Factors	**Factors' relative weights (1)**	**With aquaculture (2)**	**Without aquaculture (3)**	**With aquaculture (4)=(1)X(2)**	**Without aquaculture (5)=(1)X(3)**	**Net impact (6)=(4)-(5)**
Incomes	0.17	0.90	0.10	0.1530	0.0170	0.1360
Employment	0.05	0.86	0.14	0.0430	0.0070	0.0360
Health	0.19	0.25	0.75	0.0475	0.1425	-0.0950
Family relations	0.02	0.67	0.33	0.0134	0.0066	0.0068
Social interactions	0.03	0.83	0.17	0.0249	0.0051	0.0198
Infrastructure and services	0.04	0.83	0.17	0.0332	0.0068	0.0264
Social order	0.17	0.33	0.67	0.0561	0.1139	-0.0578
Ecosystem	0.33	0.20	0.80	0.0660	0.2640	-0.1980
Net impact (Global Priority Index)				0.440	0.560	-0.130

The relative weights in Tables 6 and 7 are summarized in columns two, three and four of Table 8. The fifth and sixth columns in the same table are calculated based on these three columns. These two columns are then used to further calculate results reported in the last column. The last row in Table 8 represents the column sums.

The numbers in Table 8 provide plenty of information. The second column shows that the shrimp farmer deem ecosystem (0.33) the most important factor in his utility, followed by Health (0.19), Income (0.17), Social Order (0.17), and so on.

The fifth and sixth columns show that aquaculture improves the shrimp farmer's well-being through the Income factor (0.1530>0.0170), the Employment factor (0.0430>0.0070), the family relations factor (0.0134>0.0066), the social interaction (0.0249>0.0051) and the infrastructure factors (0.0332>0.0068), but reduces his well-being through the Health factor (0.0475<0.1425), Social Order (0.0561<0.1139), and the Ecosystem (0.0660<0.2640).

The last column shows that aquaculture benefits the shrimp farmer the most through the Income factor (0.1360), next by Employment (0.0360), Infrastructure and services (0.0264), social interactions (0.0198), and family relations (0.0068), but costs the farmer the most through Ecosystem (-0.1980), next by Health (-0.0950), and the last by Social Order (-0.0578).

The last row shows that aquaculture's net impact on the shrimp farmer is negative (-0.13). Even though the farmer is better off with aquaculture regarding most of the factors (5 out of 8), the global score is still slightly lower with aquaculture because of the relative large weight for the factor "ecosystem". This hypothetical example shows the importance of using the AHP method instead of directly comparing factors without considering stakeholders' preference.

We have used a very simple example to illustrate the use of the AHP method in the assessment of aquaculture's social-economic impacts. The AHP method is very powerful tool that can be used to deal with the existence of sub-criteria and other more complicated situations. Also, for simplicity, we did not discuss all the technical details such as checking the consistence ratios. Interested readers can refer to the citations provided in this paper for more thorough discussion of the method.

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APPENDIX D

WELCOME REMARKS BY MR TSUKASA KIMOTO, OFFICER-IN-CHARGE FAO SUBREGIONAL OFFICE FOR CENTRAL ASIA (SEC)

Director of Aquaculture of the Turkish Government
Distinguished Experts
Colleagues
Ladies and Gentlemen

On behalf of the Director-General of the Food and Agriculture Organization of the United Nations (FAO), Dr Jacques Diouf, I have the honour and pleasure to welcome you all to the FAO Subregional Office for Central Asia (SEC), and to thank you for having accepted to participate in this Expert Consultation. I am indeed very pleased that this meeting is participated by the professional experts from different parts of the world, who are well known for their high level expertise on the subject matters which this Expert Consultation is going to deal with.

The premises of the FAO Subregional Office for Central Asia, which you are now visiting, including this conference hall, are a donation of the Government of Turkey. At the outset, I wish to express FAO's sincere appreciation to the Government of Turkey for providing us with this office building with conference facilities and for hosting this Expert Consultation meeting. Turkey and its people are well known for warm and cordial hospitality. I hope, and I am sure, that you will have a pleasant stay in Ankara, although I am afraid that your meeting has a heavy agenda.

Today, we gather here to exchange views on the socio-economic impacts of aquaculture. If I may recall the recent history, in the framework of FAO, the issue of socio-economic impacts of aquaculture was first raised at the second session of the Sub-Committee on Aquaculture of the FAO Committee on Fisheries (COFI), which was held in Trondheim, Norway, in August 2003. Recognizing the growing importance of aquaculture and the need to improve its socio-economic benefits, the Sub-Committee recommended for FAO to undertake a thematic evaluation of the socio and economic impacts of aquaculture.

At its third session, held in New Delhi, India, in September 2006, the Sub-Committee pushed this recommendation a step further by asking FAO to organize an intersessional Expert Consultation with the participation of professional aquaculture and resources economists. The mandate given to the proposed Consultation was to "agree on a widely accepted methodology for assessing socio-economic impacts of aquaculture and to determine further needs for socio-economic analyses, assessments and indicators", especially for aquaculture. The recent twenty-seventh session of the Committee on Fisheries (COFI), which met in Rome in March 2007, endorsed the request made by the Sub-Committee and, indeed, emphasized the urgent need for such a Consultation.

Your presence here responds to this request, and we are very happy to have you here today.

As the importance of aquaculture is increasingly recognized in the context of national or regional economy and food security, its socio-economic implications are a source of public debates and sometimes social conflicts. While the positive aspects of aquaculture are stressed by many, its negative aspects are highlighted by many others. Obviously, the issues related to the question of socio-economic impact assessment in aquaculture are complex. In particular, at FAO we feel that:

1. First, the nature of these impacts is not clearly understood, and
2. Second, their assessment methodology is poorly documented.

Hence, the task of this Consultation during the coming five days will be to assist us in:

1. First, identifying the socio-economic impacts of aquaculture, and
2. Second, developing a simple, easy-to-use, yet robust and universally acceptable method for measuring these impacts.

As requested by the FAO COFI Sub-Committee on Aquaculture, your kind assistance is also invited to guide us on further work you may deem necessary in this field of socio-economics of aquaculture, be it in terms of analyses, assessments, or development of specific indicators.

Before closing my welcome remarks, for those of you who may not be familiar with FAO rules and procedures, I should perhaps clarify that, regardless of your occupation and professional affiliations, you are attending this Expert Consultation in your personal capacity, and not as a representative of your government or any organization or institution to which you might belong. You are encouraged to express yourself freely and frankly, to share your opinions and provide inputs on the various subject matters covered by this Expert Consultation.

We have a few colleagues from the FAO Secretariat, who will be pleased to work with you and to facilitate your work, as necessary.

I wish you a fruitful consultation meeting and look forward to the results of your work with great interest.

Thank you.

APPENDIX E

OUTLINE FOR THE IMPROVEMENT OF THE BACKGROUND DOCUMENT: *“REVIEW OF THE SOCIO-ECONOMIC IMPACTS OF AQUACULTURE: IDENTIFICATION AND ASSESSMENT METHODS”*

1. Introduction

(1) Define the terms such as assessment and socio-economic impacts.
(2) Relate the assessment of socio-economic impacts of aquaculture to Millennium Development Goals (MDGs) with respect, for example, to the contribution of aquaculture to poverty reduction and sustainable livelihood.
(3) Clarify from the onset that socio-economic impacts of aquaculture include both tangible impacts which can be evaluated in monetary terms and the intangibles which are difficult to quantify in monetary value, and provide examples of each category.
(4) Provide the rationale for this whole exercise.
(5) Clarify the level of policy making at which the assessment technique being sought will be applied and related.
(6) Point out the applicability of the assessment techniques to different levels of development (e.g. developing countries, emerging economies, and advanced economies), different types of production (e.g. inland and coastal), different production systems (e.g. extensive and intensive), and different scales.
(7) Discuss in depth externalities and show their linkages to socio-economics to highlight the difficulties and importance of the exercise, which involve evaluating non-market and intangible variables.
(8) Use case studies to illustrate the importance of socio-economic impact assessment (illustrated in a box).

(9) Summary (main points covered in the chapter and the transition to the next chapter)

2. Identification of the socio-economic impacts of aquaculture

(1) Add in the introductory paragraph the purpose of this chapter and SIA framework.
(2) Discuss the impacts while avoiding their categorization under “positive” or “negative”.

2.1 Natural capital/resources
- 2.1.1 Land: Rent
- 2.1.2 Water: Rent
- 2.1.3 Wild stocks
  - (1) Biodiversity
  - (2) Biosecurity

2.2 Physical capital/resources
- 2.2.1 Food security
  - (1) Food supply
  - (2) Food quality and safety
  - (3) Food access
  - (4) Food stability
- 2.2.2 Infrastructure
- 2.2.3 Other industries

2.3 Human capital/resources
- 2.3.1 Employment
- 2.3.2 Health
  - ➢ Health impact analysis
- 2.3.3 Education and training
- 2.3.4 Research

2.3.5 Migration
2.3.6 Gender

2.4 Social capital/resources
2.4.1 Social institutions and legal framework
(1) Property rights
(2) Customary rights
(3) Corruption
(4) Producer organizations
(5) Community-based organizations
(6) Trade Unions
2.4.2 People's attitude (social acceptability)
2.4.3 Community cohesion and social order
(1) Morality
(2) Poaching
(3) Community organization
2.4.4 Cultural change
2.4.5 Equity
2.4.6 Indigenous people's well-being

2.5 Financial capital/resources
2.5.1 Incomes
(1) Income distribution
(2) Poverty
(3) Foreign exchange
2.5.2 Investment
(1) FDI and capital flows
(2) Private and public investment
2.5.3 Fiscal policies
(1) Taxes
(2) Foreign exchange
(3) International trade
(4) Subsidies
2.5.4 Financial institution/credit

Summary (main points covered in the chapter and the transition to the next chapter)

3. Conceptualization and measurement of the socio-economic impacts of aquaculture

3.1 A review of literature
3.1.1 Setting
(1) Plan: issues, objectives and assessment process
(2) Conceptual framework
(3) Empirical framework: delete Figure 1
(4) *Indicators*
a. Delete Table 1
b. Reorganize, expand, and substantiate the fragmented section
Data

Summary (main points covered in the chapter and the transition to the next chapter)

4. Assessment methods of socio-economic impacts of aquaculture

4.1 A broad review of relevant methods (with a summary table)
(1) Through various impacts of aquaculture identified in Chapter 2, identify appropriate assessment methods as follows:

a. Economic impact: private CBA (NPV, IRR); economy-wide impacts using input-output analysis or some variants of general equilibrium models such as Social Accounting Matrix and Computable General Equilibrium.
b. Environmental impact: value the externalities if possible using opportunity cost, revealed preference, stated preference, or other methods.
c. Social impact: value the social impacts if possible using opportunity cost, revealed preference, stated preference, or other methods.
d. Health impact: value the health impacts if possible using opportunity cost, revealed preference, stated preference, or other methods.

(2) Account for higher-order impacts.
(3) Synthesizing: If all the derived impacts are in monetary terms, perform a social benefit-cost analysis. Otherwise, try to account for non-market and intangibles in an overall analysis in addition to CBA using MCDM techniques such as AHP.

4.2 Cost-benefit analysis (CBA)

(1) Discuss the inter-temporal dimension of CBA
(2) Discuss social and private CBA in the context of aquaculture

4.3 Multiple criteria decision-making (MCDM) method: in addition to MAUT and AHP, a brief discussion of other MCDM methods

4.4 Comparison of CBA and MCDM

(1) In addition to CBA and MCDM as the main focus, include comparison of other models such as choice model.
(2) Emphasize the difficulties in implementation
(3) Expand the discussion on MCDM
(4) Discussion of the similarity of CBA and MCDM
(5) Discussion of the strengths and weaknesses of MCDM (AHP) and CBA
(6) Discussion of the applicability of CBA and MCDM under different situations (e.g., production systems, level of economic development, and level of aquaculture development, scale of production, and scale of stakeholders)
(7) Discussion of the costs of implementing CBA and MCDM
(8) A summary of the discussion to lay down a foundation for the next section

4.5 Stakeholder approach and assessment of socio-economic impacts of aquaculture

4.5.1 The conceptual framework

(1) Stakeholders

a. Define stakeholders
b. Emphasize the importance of the methods used to select stakeholders

(2) Factors

a. Impacts on stakeholders' well-beings
b. The net impact on stakeholders' well-being

- Discuss the limitations and dangers of aggregation methods
- Discuss different levels of aggregation

4.5.2 The empirical framework

- Complete Table 4 based on the expert opinions provided in the workshop

Summary (main points covered in the chapter and the transition to the next chapter)

5. Illustration of selected assessment methods in aquaculture

- Expand the section by including some case studies which illustrate several different situations (e.g.
- scales, systems, economic development levels, and sectors) using CBA, AHP and others.

6. Conclusions and recommendations

7. References

The Expert Consultation on the Assessment of Socio-economic Impacts of Aquaculture was held in Ankara, Turkey, from 4 to 8 February 2008. It identified the many positive and negative impacts of aquaculture with their far-reaching socio-economic implications. While they agreed that multi-criteria decision-making (MCDM) framework using analytical hierarchy process (AHP) as a measurement technique is a suitable method for assessing socio-economic impacts of aquaculture, experts recognized that other methods such as the costs benefits analysis (CBA) could also be used depending on circumstances. They recommended that case studies be carried out in a certain number of developed and developing countries on assessing the socio-economic impacts of aquaculture using AHP, CBA and another technique in order to test and compare the applicability and results of these methods. They also suggested developing a user guide on the implementation of these methods and build capacity in developing countries in using them, and identified other needs for future work in socio-economics of aquaculture.

ISBN 978-92-5-106041-4 ISSN 0429-9337

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TR/M/I0277E/1/08.08/1400