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COMMITTEE ON FISHERIES

SUB-COMMITTEE ON AQUACULTURE

Sixth Session

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ASSESSING AND MONITORING THE AQUACULTURE SECTOR PERFORMANCE: IMPORTANCE, ISSUES AND CHALLENGES

Executive Summary

By generating important sales revenues, creating employment, paying better labour incomes including wages and salaries, producing higher profits for producers and traders and bringing higher tax and export revenues into national economies, and by supplying more high quality animal proteins as well as minerals, vitamins and fatty acids, aquaculture has, in recent years, shown its potential to generate important benefits to society and to contribute to the economic and social well-being of humanity. Aquaculture can also ease income distribution disparities in favour of the poor. At the same time, where it has not been properly conducted, aquaculture has often produced unintended effects on society, mostly through environmental damages. If properly conducted, systematic and continuing assessment and monitoring of the sector performance will provide policy makers, investors and consumers with timely and adequate information for guided decision making, which will, in turn, impact on the development of the sector and will ensure that the benefits accruing from the sector outweigh its costs to society. This paper shares progress made in assessing and monitoring the performance of aquaculture, underlines outstanding issues and challenges and seeks advice on the way forward. The FAO Secretariat and various researchers have identified quantifiable indicators and developed practical assessment frameworks as well as a number of techniques that can be used to quantitatively evaluate many aspects of the aquaculture performance. The issue remains the absence of user-friendly forms of these tools and the lack of forecasting capabilities for most of them. There are also factors that cannot be predicted, especially on the environmental side. At a time where basic data and statistics are still largely unavailable nationally, regionally and globally, these methods are also generally data intensive, time consuming and, therefore, economically prohibitive. It seems that addressing these issues will involve financial support from governments and donors, technical expertise from research communities and cooperation from the private sector. The solution will also require policy innovations. The Sub-Committee is invited to: (i) comment, revise the information presented in this document as appropriate and suggest other issues regarding assessment and monitoring of the sector performance; (ii) share national experiences on the sector performance assessment and monitoring, especially with respect to sources of data and information and the use of results from this task in policy making; and provide guidance to the Secretariat on how to proceed with the issue of assessment and monitoring of sector performance.

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1) comment, revise the information presented in this document as appropriate and suggest other issues regarding assessment and monitoring of the sector performance;
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INTRODUCTION

1. The performance of any sector including aquaculture can be understood as a two-sided equation. On the one side, there are benefits. On the other side, there are costs.

2. In the recent past, aquaculture has shown its potential to generate important benefits to society and to contribute to the well-being of humanity. For example, with an 8-percent annual growth rate over the past three decades, aquaculture produced 73 million metric tonnes worldwide in 2009[1], which represents 39 percent of the mass of aquatic animals and plants produced from both aquaculture and capture fisheries.

3. From 1990 to 2007, per capita world fish consumption increased by 27 percent (from 14 kg in 1990 to 17 kg in 2007) despite a 26-percent growth in the world population during this period. This increase in fish consumption is mainly attributed to aquaculture growth[2].

4. Aquaculture growth not only makes more aquatic products for home consumption available, but it also results in other enhanced economic, social and environmental benefits to society.

5. **Economically,** aquaculture growth can lead to generating more sales revenues, creating employment, paying better labour incomes including wages and salaries, producing higher profits for producers[3] and traders and bringing higher tax and export revenues into national economies4;[5];6.

6. Along with better labour incomes, higher profits and taxes contribute to enhancing countries' gross domestic products (GDP), and, therefore, their economic performance. In 2008, aquaculture brought about 105 billion dollars in the world economy, which represents 53 percent of the total value of aquatic products that year. In comparison to ten years before (1998), where aquaculture produced 47.33 billion dollars, the sector's contribution to the world economy grew by 121 percent. In some countries, especially developing economies, this contribution can be as important as 10 percent[7].

[1] FAO FishStat 2010.
[2] For example, during this period, the world recorded a mere 5-percent increase in capture fisheries production and aquaculture contributed 47 percent of direct human fish consumption.
[3] Especially in the case of large-scale commercial aquaculture.
[4] Aguero, Max and Exequiel Gonzalez. 1997. Aquaculture economics in Latin America and the Caribbean: a regional assessment. In Charles et al. ed.; Aquaculture Economics in Developing Countries: Regional Assessments and an Annotated Bibliography, FAO Fisheries Circular No.932. Rome, Italy.
[5] Hishamunda Nathanael, Junning Cai and PingSung Leung. 2009. Commercial aquaculture, economic growth and poverty alleviation. FAO Fisheries and Aquaculture Technical Paper No …..
[6] Aguero, Max and Exequiel Gonzalez. 1997. Aquaculture economics in Latin America and the Caribbean: a regional assessment. In Charles et al. ed.; Aquaculture Economics in Developing Countries: Regional Assessments and an Annotated Bibliography, FAO Fisheries Circular No.932. Rome, Italy.
[7] Nathanael Hishamunda, Pedro B. bueno, Neil Ridler and Wilfredo G. Yap. Analysis of aquaculture development in Southeast Asia. A Policy perspective. FAO Fisheries Technical Paper 509, pp 69. Rome, Italy.

7. In addition to its direct contribution to Gross Domestic Product (GDP), aquaculture induces value-addition in downstream industries such as in seed, feed, veterinary products, machinery and construction. Induced value addition also occurs in upstream industries including processing, transportation and warehousing, distribution and leisure fishing. In some instances, the whole value chain of the county's aquaculture and fishery sector has contributed a significant share of the country' GDP.[8]

8. The contribution of aquaculture to national economies improves, in part, because profits from the sector and savings from employees in the sector improve. Improved business profits from aquaculture and savings from employees in the sector provide additional funds for public investments such as in human capital and in road, school, sanitary and other infrastructure.

9. Better infrastructure of this nature and improved investment in human capital will provide new impetus to economic activity, benefit local businesses and communities, and hence, further enhance economic performance and growth. There are many instances where economic development, especially the development of isolated regions, has discouraged outward migrations and strengthened communities[9].

10. An important determinant of community stability and strengthening is employment. With aquaculture growth, the world has experienced an impressive expansion in on-farm and off-farm employment in the sector. It has been estimated that in 2008 aquaculture created about 11 million full-time jobs worldwide,[10] which provided employment to 0.3 percent of the global labour force and 0.8 percent of the global labour force in agriculture[11].

11. These numbers may have been underestimated because, in many countries, statistics do not distinguish between fishers and fish farmers. Results of a recent FAO estimation of employment in the aquaculture sector corroborates this assertion. They indicate that the sub-sector provides over 30.5 million full-time-equivalent jobs, including about 21.5 million on-farm and nearly 9 million off-farm positions[12].

12. Regardless of the accuracy of these numbers, the more conservative estimation of the 11 million jobs in 2008 represents an 85-percent increase in aquaculture employment compared to 1990.

13. From a **social** point of view, by supplying more high quality animal protein as well as minerals, vitamins and fatty acids aquaculture growth contributes to food security. Higher household incomes generated by aquaculture related activities can also contribute to food security by improving people's access to food. Moreover, aquaculture growth can ease income distributional issues in favour of the poor because the major share of aquaculture production comes from small- to medium-scale farmers whose incomes are generally low. In addition, public infrastructure and services such as roads, schools and hospitals directly provided or induced by the aquaculture sector can indirectly improve the social welfare of communities.

14. **Environmentally**, the benefits from aquaculture growth can consists in increased land productivity by utilizing more sodic land to culture fish, improved water quality through farming of more molluscs or aquatic plants, and enhanced stock of wild species through extensive stock enhancement programmes.

[8] China Fishery Statistics Yearbook 2009 (for China's value-added and employment in aquaculture), World Bank's World Development Indicators Database (for China's GDP and agriculture value-addition).
[9] Ridler, Neil and Nathanael Hishamunda. 2001. Promotion of sustainable commercial aquaculture in sub-Saharan Africa. Volume 1: Policy framework.FAO Fisheries Technical Paper 408/1, pp 67. Rome, Italy.
[10] FAO. State of World Fisheries and Aquaculture 2010.
[11] FAOSTAT (PopStat) (for economically active population, i.e., labour force).
[12] Diego Valderrama, Nathanael Hishamunda and X. Zhou. 2010. Estimating employment in world aquaculture. FAO Aquaculture Newsletter No. 45, August 2010, pp. 24–25.

15. There is an increasing belief among the scientific community that, because of the expected population and income growth, urbanization and increasing consumer preference over healthy food, global demand for seafood will continue growing.

16. As production from capture fisheries shows signs of remaining constant, at best, for some more years to come, a rise in global demand for seafood represents a great opportunity for further aquaculture growth. Other things being equal, an increase in demand for seafood will lead to higher profits in the sector. Increased profit opportunities will entice more entrepreneurs in the industry. The higher the number of entrepreneurs in the industry, the larger the size of the aquaculture supply. An expansion in aquaculture supply will yield more benefits to society.

17. Notwithstanding these promising prospects for improved benefits, aquaculture growth can also be costly to society. The cost is essentially environmental.

18. If not guided and monitored properly, aquaculture expansion may, for example, cause the degradation of land habitats (including mangroves), land salinization, eutrophication, detrimental algal blooms, chemical pollution with its negative impacts on consumers' health[13], reduction of wild stocks through seed collection, endangering bio-diversity through escapees[14] and reduction of fish resistance to diseases[15].

19. This dark environmental side of aquaculture bears economic and social costs to society. The latter must be accounted for when assessing and monitoring the performance of the sector.

20. This statement is in line with one of the outcomes of the Third Session of this Sub-Committee which underscored the importance of identifying and quantifying the socioeconomic impacts and underlined the need for a balanced approach to assess both the positive and negative socio-economic impacts of aquaculture.

21. While existing literature provides extensive information on the qualitative assessment of these complex socioeconomic costs and benefits of aquaculture to society, progress on their quantitative evaluation remains limited.

22. The purpose of this paper is to recall the importance of properly assessing and monitoring the performance of aquaculture, share progress made in this respect and underline outstanding issues and challenges. The aim is also to seek advice on ways of contributing to addressing these issues in general and on the way forward on assessing and monitoring aquaculture performance in general.

IMPORTANCE OF ASSESSING AND MONITORING AQUACULTURE PERFORMANCE

23. If properly conducted, a systematic and continuous assessment and monitoring of the sector performance will provide interested stakeholders with timely and adequate information for decision making.

24. For policy makers, a quantitative evaluation of the sector is particularly essential when it is done relative to other sectors of the economy with which it competes for productive resources. Knowledge of the relative performance of the sector may help them make guided decisions as to how best to allocate limited public resources amongst different sectors of the economy and, therefore, determine how best to provide the much needed support to aquaculture for its adequate development.

25. Perhaps because of the low contribution of the sector to national economies, this support, which can be in the form of funding from the public purse or non-monetary incentives through policies and regulations, has not always been forthcoming, especially in developing economies. Yet, as a young industry, aquaculture often needs sizeable support.

[13] Holmer, M.,K. Black, C.M. Duarte, N. Marba, I. Karakasis. 2008. Aquaculture in the Ecosystem. Springer.
[14] Marra, J. 2005. When will we tame the oceans? Nature 436:175–176.
[15] Mcleod, C., J. Grice, H. Campbell and T. Herleth. 2006. Super Salmon: the industrialization of fish farming and the drive towards GM technologies in Salmon production. CSaFe, Discussion Paper 5. University of Otago.

26. There is another policy reason for assessing and monitoring the performance of aquaculture. Where aquaculture performance has not been carefully assessed and monitored, results have generally been damaging. Shrimp farming is a good illustration. Prompted only by myopic perspectives of quick profits, many farmers in a number of countries adopted farming practices that caused mangrove destruction and land salination and prompted disease outbreaks in the late 1980's. These environmental and disease problems have since prompted governments to regulate the industry which was near collapse[16].

27. With globalization, aquaculture has become an international and complex business operating in many countries and involving many species cultured under different farming environments and systems, using different technologies and targeting different markets.[17]

28. Under the global competitive environment, aquaculture private investors and managers need up-to-date information on the sector's current performance and insights on its growth prospect in order to make rational business decisions.

29. Nowadays, a consumer decision to purchase an aquaculture product is no longer determined solely by its price and quality. More and more consumers require information on the way it was produced. They, inter-alia, wish to know if the fish was produced in an environmentally friendly manner or if it was processed according to established animal welfare standards. Responses to these and other questions require adequate and sustained assessment and monitoring of the performance of the sector.

RECENT DEVELOPMENTS, OUTSTANDING ISSUES AND CHALLENGES

30. Assessment and monitoring of the aquaculture sector performance is a process of knowledge generation, dissemination and utilization for decision making.

31. Knowledge generation generally requires a *practical assessment framework* to illustrate the concept under measurement. A clear understanding of the concept facilitates the identification or development of its *evaluation technique/model/method.*

32. Once the technique is identified or developed, basic robust data is required in order to apply the technique and generate quantitative information of interest in gauging this performance. This information is provided through *quantifiable indicators*.

33. Existing literature provides assessment frameworks which can be used to measure aquaculture performance. An example is the framework which was developed by FAO to evaluate the environmental and socioeconomic impacts of aquaculture[18]. This assessment framework was validated by the 2008 "FAO Expert Consultation to identify methods on assessment of socioeconomic impacts of aquaculture"[19].

34. In the same framework, FAO and the World Fisheries Trust (WFT) organized, in 2006, an Expert Workshop on Comparative assessment of the environmental costs of aquaculture and other

[16] Nathanael Hishamunda, Pedro B. bueno, Neil Ridler and Wilfredo G. Yap. Analysis of aquaculture development in Southeast Asia. A Policy perspective. FAO Fisheries Technical Paper 509, pp 69. Rome, Italy.
[17] In 2009, aquaculture was engaged in at least 175 countries and involving at least 368 farming species under different farming environments (freshwater, brackish and marine) and farming systems such as pond, cage, pen, raceway, tank, and re-circulating system (Data source: FAO FishStat Plus).
[18] Examples include: Nathanael Hishamunda, Junning cai and PingSun Leung. 2009. Commercial aquaculture and economic growth, poverty alleviation and food security. Assessment framework. FAO Fisheries and Aquaculture Technical Paper 512, pp.58. Junning Cai, PingSun Leung and Nathanael Hishamunda. 2009. Assessment of comparative advantage in aquaculture. Framework and applications in developing countries. FAO Fisheries and Aquaculture Technical Paper 528, pp.87.
[19] FAO 2008 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.

food production sectors. The goal was to identify methods for a balanced picture of the environmental costs of all food-producing sectors [20].

35. FAO has also exerted efforts in developing or compiling *indicators* with the purpose of assessing economic, social and environmental performance of the sector be it for commercial or non-commercial small-, medium- and large-scale operations[21];[22];[23].

36. Additional efforts were made to develop and compile indicators on aquaculture development by other stakeholders. An example is a multi-stakeholder workshop which was organized in Oostende, Belgium, in 2005 to develop indicators for sustainable aquaculture development in Europe.[24]

37. Unfortunately, on the one hand, many of these indicators are not quantifiable; they are descriptive. Descriptive indicators have not always convinced policymakers to include aquaculture in their development agenda nor entrepreneurs to invest in the sector.

38. On the other hand, perhaps d ue to the lack of user-friendly techniques to compute them, the ones which are quantifiable are often left to intended users to measure.

39. However, because of the complexity of this exercise, which also requires gathering basic statistics, most intended users of these indicators often revert to existing publications for quantified indicators. The danger is that those who lack the research capacity may not be able to locate them. Many more may also not have the required capacity to assess the accuracy of the information found in the literature.

40. Because of the paucity of published indicators, there is also the danger of using an incomplete set of individual indicators to take a decision that may affect the sector as a whole. Using individual indicators in this way might lead to wrong inferences and misleading policies.

41. For example, an increasingly popular recommendation to farmers in the promotion of aquaculture is the farming of low-trophic species such as herbivorous or filter-feeder finfishes. The underlying argument is that low-trophic species tend to have lower Food Conversion Ratios (FCRs) as opposed to high-trophic species such as crustaceans and carnivorous finfishes.

42. While this recommendation is seemingly technically sensible, it can be challenged from a socio-economic point of view; there is no established evidence that farming low-trophic species results in a higher contribution to farmers' livelihood than farming high-trophic species.[25] After all, the end goal of farming is the improvement of the well-being of the famer and the community. Individual indicators provide information on specific aspects of the sector performance, not on the sector as a whole. Using them separately to make inferences on the sector is an oversimplification which may lead to wrong conclusions and often bad policy advice.

43. Although each has its own caveats, a number of *methods/techniques/models* are now available to quantify indicators and evaluate many aspects of the aquaculture performance. The "Life cycle

[20] Bartley, D.M.; Brugère, C.; Soto, D.; Gerber, P.; Harvey, B. (eds), 2007. Comparative assessment of the environmental costs of aquaculture and other food production sectors: methods for meaningful comparisons. FAO/WFT Expert Workshop.
24-28 April 2006, Vancouver, Canada. FAO Fisheries Proceedings. No. 10. Rome, FAO. 2007. 241p.

[21] See Nathanael Hishamunda, Junning cai and PingSun Leung. 2009. Commercial aquaculture and economic growth, poverty alleviation and food security. Assessment framework. FAO Fisheries and Aquaculture Technical Paper 512, pp.58. Junning Cai, PingSun Leung and Nathanael Hishamunda. 2009. Assessment of comparative advantage in aquaculture. Framework and applications in developing countries. FAO Fisheries and Aquaculture Technical Paper 528, pp.87.

[22] *Environmental impact assessment and monitoring in aquaculture (FAO Fisheries and Aquaculture Technical Paper 527, 2009);*

[23] *Measuring the contribution of small-scale aquaculture: an assessment* (FAO Fisheries and Aquaculture Technical Paper 534, 2009).

[24] CONSENSUS (2005) Defining Indicators for Sustainable Aquaculture Development in Europe: A multi-stakeholder workshop (Oostende, Belgium, November 2005).

[25] Cite Hasan's paper

analysis" is one of them. It is commonly used to account for the environmental impacts of a sector's entire value chain. Recently, the method was used to assess the environmental costs of aquaculture at the global level.[26] While the method can be used to systematically estimate the environmental consequences, it is nevertheless data intensive, time consuming and, therefore, economically prohibitive.

44. Another method is the Benefit-Cost analysis, which is often used to assess the net impacts of a sector's positive and negative socioeconomic impacts. It measures all the benefits and costs in a single monetary unit so that they can be aggregated to derive the net impact. Though the method and its results are understandable and generally acceptable to policymakers and the general public, it is difficult to estimate the monetary value of non-market, non-economic and/or intangible variables.

45. An additional issue in assessing and monitor the performance of the aquaculture sector is the lack of forecasting capabilities of existing models in this area. These models usually provide only current snapshots of the sector performance; they fail to account for potential changes of this performance which can occur over time. A timely knowledge of this information allows policymakers, producers and other stakeholders in the sector to take the right course of action.

46. There are also factors which cannot be predicted, especially on the environmental side. Unexpected important consequences can arise from these changes no matter how carefully a course of action has been planned out. Yet, these models often fail to account for these factors.

47. There have been efforts in quantitatively forecasting the sector's future situations.[27] A notable progress is the inclusion, since 2011, of aquaculture in OECD-FAO Agricultural Outlook, a biennial publication on forecasting agricultural sectors' situation 10 years ahead. However, most information on the sector's future prospects often remains limited to qualitative analyses or *ad hoc* speculations based on anecdotal evidence or expert opinions[28].

48. Recently, FAO initiated an activity which aims at contributing to address this and other issues. The specific aim is to identify and compile indicators for assessing and monitoring the economic, social and environmental performance of the aquaculture sector as well as to assess and monitor the status and trends of the sector's growth parameters.

49. The goal is also to develop a mathematical tool which should serve as a template and database to facilitate the collection and storage of data needed to assess and monitor the performance of the aquaculture sector, allow users to conveniently calculate economic, social and environmental indicators as well as growth parameters needed to assess and monitor the performance of the aquaculture sector.

50. The tool should also allow users to automatically illustrate the quantified indicators and growth parameters through tables and/or graphs. It shall be flexible enough to allow users to assess the performance of aquaculture sub-sectors when needed, especially *small-scale aquaculture*. However, extensive consultations on this endeavour will be needed before these tools can be widely disseminated.

51. Efforts to assess and monitor the performance of the aquaculture sector are also limited by the lack of adequate data. The problem occurs in terms of availability and quality.

52. Basic collected or estimated data and statistics are essential raw materials for the assessment and monitoring of the aquaculture sector performance. For example, to assess the performance of aquaculture in terms of employment, a socio-economic dimension of the sector, one would need data

[26] WorldFish Center's report: Blue Frontiers: Managing the Environmental Costs of Aquaculture (by Hall, S.J., A. Delaporte, M. J. Phillips, M. Beveridge and M. O'Keefe), 2011.
[27] Ye (1999), IFPRI's Fish 2020; FAO Fisheries Circular No. 1001 (Brugere and Ridler); OECD-FAO model; WB-FAO Fish 2030.
[28] Nathanael Hishamunda, Florence Poulain and Neil Ridler. 2009. Prospective analysis of aquaculture development; the Delphi method. FAO Fisheries and Aquaculture Technical Paper 521, pp.93.

on full-time employment in aquaculture, in fisheries, in agriculture and total labour force in an economy.

53. Likewise, the assessment of the aquaculture performance in terms of its contribution to national economies will require, inter-alia, quantities of aquaculture products, prices of aquaculture products, information to estimate direct and indirect value addition of aquaculture and capture fisheries to GDP, etc. Such data are not always available.

54. The problem may become more complicated in the case of assessing positive and negative aquaculture environmental impacts. For example, data will be needed to assess the impact of the sector on soil, water, biodiversity, etc. If one takes biodiversity alone, a fundamental requirement for sustainable development, information on change in genetic diversity, change in species diversity and change in ecosystem diversity (natural habitats) will be required[29].

55. The issue of availability of data and statistics on the status and trends of aquaculture development has been recognized and emphasized in several previous sessions of this Sub-Committee[30]. A great deal of effort has been deployed towards addressing this problem.

56. Following the Sub-Committee's advice, FAO organised an expert consultations on this topic. The goal was to seek experts' guidance on practical ways of addressing the issues of availability of suitable data and statistics.

57. In 2004, FAO also developed the "Strategy and Outline Plan for Improving Information on Status and Trends of Aquaculture". In 2008, FAO established a Coordinating Working Party (CWP) on Aquaculture Statistics. In both cases, the aim was to facilitate the collection of aquaculture data and statistics.

58. A CWP Handbook for Aquaculture Statistics is being developed to streamline the definitions, standards and methodologies required for data collection and reporting.

59. Moreover, FAO compiles and disseminates basic aquaculture statistics mainly through the FAO Yearbook of Fishery and Aquaculture Statistics and the associated databases FishStat (FishStat Plus and FishStat J). So far, these are the best sources of statistics on aquaculture and fisheries production and international trade of fish and fishery products at the global level. Data obtained from these sources are useful, but, they are often incomplete and may need improvement.

60. In addition to FAO sources, there are databases providing aquaculture statistics at the regional level. Examples include GLOBFISH, EUROSTAT, SIPAM (Information System for the Promotion of Aquaculture in the Mediterranean) and SEAFDEC (Southeast Asian Fisheries Development Centre). However, these too contain important gaps.

61. A number of countries publish official aquaculture statistics periodically. Some of these publications may contain comprehensive and detailed statistics on aquaculture production including quantity, value and value addition. Value and value addition in related industries and information on production factors such as land area farmed, seed and labour are also provided. They may also contain information on product processing and trade, fishery and aquaculture administration, research and extension, losses from disasters and financial situations of fishery or aquaculture households.[31] Unfortunately, such countries are still very few. Where this information exists, robust indicators will be produced alternatively and notably in most developing countries, second-best proxies will be developed.

[29] Lisa Segnestam. Environmental Performance Indicators. A Second Edition Note. Paper No 71. The World Bank. 1999.

[30] COFI:AQ/I/2002/5 (Need for better reporting on the status and trends of aquaculture development), COFI:AQ/II/2003/5 (Improving the status and trends reporting on aquaculture), COFI:AQ/III/2006/4 (Towards improving information on the status and trends in aquaculture development), and COFI:AQ/V/2010/8 (Coordinating Working Party (CWP) on Fisheries Statistics).

[31] An example is the China Fishery Statistical Yearbook.

CONCLUSION

62. This paper recalls the importance of assessing and monitoring the performance of the aquaculture sector and shares recent developments in this area. It also indicates how challenging this process can be. The challenges range from identifying appropriate indicators and getting solid frameworks and models to accurately measure them in order to have robust data to apply to the models.

63. There are frameworks and models which can be used to complete this task. The issue remains the lack of *user-friendly forms* of these tools to compute the indicators needed. FAO has initiated some activities to contribute to filling this void, but, collective effort is needed for this issue to be fully and effectively addressed.

64. Effectiveness of the sector performance assessment and monitoring entails not only modelling including identification and measurement of practical and realistic indicators, but, it also requires proper data.

65. Despite efforts exerted in data collection, many important statistics needed for assessment and monitoring of the sector as well as for its better management are still largely unavailable nationally, regionally and globally. These data include the use of land and water in aquaculture, employment and household incomes provided by aquaculture and related businesses, prices of aquaculture products and costs of inputs, detailed trade data, structure of farming operations such as farming systems and technology, etc.

66. Efforts have been exerted to use estimations to fill the void of absent statistics, such as employment[32] and land use[33] in aquaculture and related business. However, although such estimations provide valuable information, their accuracy cannot always be assured.

67. Estimations are common practices for filling in small amounts of missing data based on large quantities of observed statistics. Unfortunately, they tend to be less accurate when small amounts of observed data are used to estimate large quantities of missing variables. This, unfortunately, is a common practice in many efforts in the assessment and monitoring of the aquaculture sector performance. In addition, these estimations may differ significantly because of the different methodologies used by different authors.

68. An alternative is to conduct censuses or surveys at the regional or national level to provide more current and consistent basic data. However, censuses/surveys often involve financial support from governments and donors, expertise from research communities and cooperation from the private sector. These resources are not always at hand.

69. This cooperation will be needed even more as the sector continues to expand and the need for its assessment and monitoring will grow higher. Availability of basic data and statistics will also require policy innovations, which implies strong government support at the national, regional and global levels.

70. For example, a few large commercial aquaculture companies have started reporting their environmental and social performance in annual reports that used to focus only on their economic performance.[34] Appropriate policies could be set up for other companies to follow suit.

71. Furthermore, quantitative information could be obtained through certification programmes. Just like food producers are being required to provide information on the food composition in terms of nutritional content, certified aquaculture producers could also be required to provide quantitative

[32] Valderrama, D., Hishamunda, N. & Zhou, X. 2010. Estimating employment in world aquaculture. FAO Aquaculture Newsletter No. 45, August 2010, pp. 24–25.

[33] WorldFish Center's report: Blue Frontiers: Managing the Environmental Costs of Aquaculture (by Hall, S.J., A. Delaporte, M. J. Phillips, M. Beveridge and M. O'Keefe), 2011.

[34] Examples include the "sustainable development reports" by seafood companies, AquaChile (Chile), Cermaq (Norway), Marine Harvest (Norway) and Sanford (New Zealand), under the Global Reporting Initiative (GRI). https://www.globalreporting.org/information/about-gri/what-is-GRI/Pages/default.aspx

information on the subject under certification. For example, amount of CO2 emissions and percentage of retailed value that goes to wage incomes, figures on employment could be requested.

72. Research communities can also play more active roles in this respect. An in-depth analysis of aquaculture's environmental and socioeconomic impacts and the sector's growth prospects entails expertise that may only be readily available in research communities. One key issue is how to motivate researchers to conduct more issue-based and policy-oriented research.

SUGGESTED ACTION BY THE SUB-COMMITTEE

73. The Sub-Committee is invited to:

a) Comment, revise the information presented in this document as appropriate and suggest other issues regarding the assessment and monitoring of the sector performance;
b) Share national experiences on the sector performance assessment and monitoring, especially with respect to sources of data and information and the use of results from this practice in policy making;
c) Provide guidance to the Secretariat on how to proceed with the issue of assessment and monitoring of sector performance.