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Scenario Planning as a Management Tool for Sustainable Aquaculture

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Abstract

Aquaculture continues to be the fastest-growing food producing sector in the world. As the world's human population continues to expand beyond 7 billion, the reliance on aquaculture products as a cheap source of protein continues to increase. However, over the years various aspects of this sector have come under scrutiny due to the negative impacts on the aquatic environment and more importantly the sustainability of the aquaculture industry itself with respect to environmental issues and the utilisation of resources. Scenarios are a powerful way to expose the thinking around issues of mutual concern and to explore ways of facing them. The overall impact of scenario planning is a function of how deep they are able to penetrate the thinking of researchers, governments and policy makers to critically consider what choices exist for issues of common concern. The present paper addresses the case of the aquaculture industry as a whole. The development of scenarios on the future of aquaculture is a paramount if the socio-economic, environmental and ecological impacts of aquaculture are to be ameliorated and more importantly, to focus aquaculture on the path of sustainability. The methodology applied for the study was, the principles of scenario planning, namely thinking creatively about possible complex and uncertain futures by considering a variety of possible futures uncertainties in a system rather than focus on the accurate prediction of a single outcome. The aim of the study was to create scenarios on the internal driving forces that could shape the aquaculture practices and direct it on the path of sustainability and four Scenarios were created.

Key words: aquaculture, scenarios, sustainable, environment, deriving forces, innovation

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1.0. INTRODUCTION

Aquaculture is the fastest-growing sector of the world food economy, with 10-12 percent rate of increase each year, compared with only 1.4% for capture fisheries and 2.8% for terrestrial meat production systems (FAO, 2003). As the world's human population continues to expand beyond 6 billion, its reliance on farmed fish as an important source of protein continues to increase (Naylor *et al.*, 2000). It is expected that by 2030, aquaculture will dominate fish supplies and more than half of the fish consumed is likely to originate from this sector (FAO, 2000). Enhancing food security and alleviating poverty are major and complementary global priorities. Aquaculture has a special role in achieving these objectives because, firstly, fish is a highly nutritious food that forms an essential, if not indispensable, part of the diet of a large proportion of people in developing countries. Secondly, it could improve economic activity of rural communities by converting marginal lands into ponds for fish farming.

Over the years various aspects of this industry have come under scrutiny due to their impacts on communities, the aquatic environment, other aquatic organisms, diseases, pollution and more importantly the sustainability of the aquaculture industry itself with regards to its impacts on the environment and utilisation of resources. An important issue that has always come up for discussion is the reliance on fishmeal in fish feeds. Fishmeal is produced by industrially converting small-size fish into meal. These small-size fish which could be used for human consumption is some regions of the world is converted to fishmeal due the economics of scale. Due to the high cost of fishmeal, fish feeds accounts for 50-60% of aquaculture production cost. Coupled with this high cost of production are the issues of sustainability, the environmental impacts and the ethical issue of catching fish to feed fish.

In order to ensure the survival of the aquaculture industry, it is imperative that the principles of sustainable aquaculture as defined by the FAO, the European Commission, and environmental bodies such as World Wide Fund for nature are adhered to. Sustainable aquaculture takes its roots from sustainable development as defined by the Brundtland commission (1987), as development in which present generations find ways to satisfy their needs without compromising the chances of future generations to satisfy theirs. Few would disagree with this definition. While we all agree that sustainability is essential, the difficulty arises in defining the term in relation to aquaculture. Two aspects of the aquaculture industry that tend to preoccupy its critics are the environmental impacts, and the use of 'industrial fisheries' to provide fishmeal and fish oil to feed piscivorous fish. Researchers involved with aquaculture however, points out that, there is the need to look at the whole process, including the market, productivity, social equity, economic feasibility as well as the physical impacts of aquaculture. This is further complicated by the sheer diversity of the sector, which ranges from small backyard fishponds to large, highly commercialised and automated operations.

Scenario planning is a systematic method for thinking creatively about possible complex and uncertain futures. The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather to focus the accurate prediction of a single a single outcome (Peterson et al. 2003). A scenario is defined as a structured account of a possible future. Scenarios describe futures that could be rather than futures that will be (Van der Heijden, 1996). In essence, scenarios are alternative dynamic stories that capture key ingredients of our uncertainty about the future of a study system. Scenarios are constructed to provide insight into drivers of change, reveal the implications of current trajectories and illuminate options for action. Scenario planning is somewhat similar to adaptive management (Walters, 1986), an approach to management that takes uncertainty into account. Scenario planning is most useful when there is a high level of uncertainty about the system of interest and system manipulations are difficult. Therefore this study was conducted with the aim to create scenarios on the internal driving forces that could shape the aquaculture practices and direct it on the path of sustainability.

2. METHODOLOGY

2.1 Scenario Planning

Scenarios offer an alternative environment in which today's decisions may be played out. They are neither predictions nor strategies; they are descriptions of possible futures with an emphasis on events and trends. Scenarios are designed to highlight opportunities and risks inherent in specific strategic issues.

Three main reasons exist for choosing the scenario methodology as the vehicle for this study:

- **Anticipation and leverage of change**: The scenarios will help identify surprises and discontinuities in trends and those elements identified as crucial to supporting the reform/ transition process. As such, it should be easier to identify pitfalls and provide possibilities to leverage new opportunities as well as produce robust and resilient strategies for the future;

- **Stimulate new ways of thinking**: Scenarios encourage thinking beyond traditional approaches to problem solving and exploitation of opportunities. They have the power to break stereotypes and this new way of thinking can serve as a catalyst for radical changes.

- **Reducing future risk:** The use of scenarios can help the aquaculture industry better determine the outcomes of certain actions before they are actually taken.

3. SCENARIOS FOR SUSTAINABLE AQUACULTURE

3.1 Scenario Planning on Aquaculture in 2050

Aquaculture is the fastest-growing sector of the world food economy, with 10-12 % rate of increase each year. As the world’s human population continues to expand beyond 7 billion, reliance on farmed fish as source of protein continues to increase. It is expected that by 2030, aquaculture will dominate world fish supplies and more than half of the fish consumed is likely to originate from this sector (FAO, 2000). This prediction is based on the projections on current production levels as shown in figure 1.

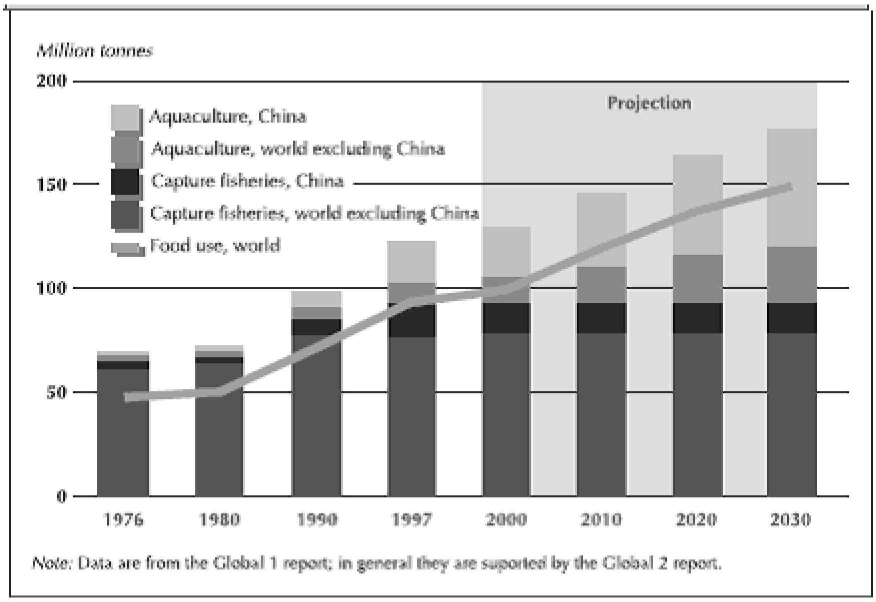

Figure 1. World Fish Production and Food use consumption 1976-2030. (Source: *The state of World Fisheries and Aquaculture, FAO report 2002*)

The development of scenarios on the future of aquaculture, an industrial process of raising fish, crustaceans, molluscs and aquatic plants for human consumption and other purposes in the aquatic medium is essential. Several driving forces which were recognised as internal forces (biotechnological innovations in feeds, disease control, reproduction and environmental control) are likely to shape the way aquaculture is practiced in the future. The internal driving forces of aquaculture are changing by the day with new scientific developments. These forces are exerting a strong influence on the physical structures and the manner in which aquaculture is practice today and would be practise in the future.

3.1.1 *Scenarios on Internal Driving Forces of Aquaculture*

Biotechnological innovations - Disease and environment

Description of Scenario Parameters

The four scenarios below depict the internal driving forces that will characterize aquaculture by 2050 (Figure 2). The development of biotechnological innovations to the fishmeal problem is envisaged where cheap alternatives such as plant proteins, genetically modified plants enriched with the deficient amino acids and single cell protein produced from microorganisms using agro-waste and waste products.

Firstly, biotechnological innovations are expected to lead to a break-through in the artificial reproduction of most of preferred fish species such as the cod, tuna, eel and aquarium species whose reproduction in captivity has been a bottleneck till date. Secondly, in the area of disease and environmental control, it is envisaged that disease control will see a lot of advancement. Vaccine development to combat and fight diseases in aquaculture will rapidly accelerate within this period. Similarly, the use of immune-stimulants and probiotics to prop immune response of culture fish will become a routine fish husbandry practice, as the emphasis will shift from disease control to prevention.

Environmental control will foresee the evolution of culture systems (tank systems, cages, recirculation systems, ponds) that effectively treat their wastes and effluents thus, completely eliminating the environmental pollution that are characteristic of present systems. Sustainable aquaculture will be the order of the day as aquaculture will be a net producer of fish and not just a through-put of converting one type offish in the form offishmeal to a preferred fish.

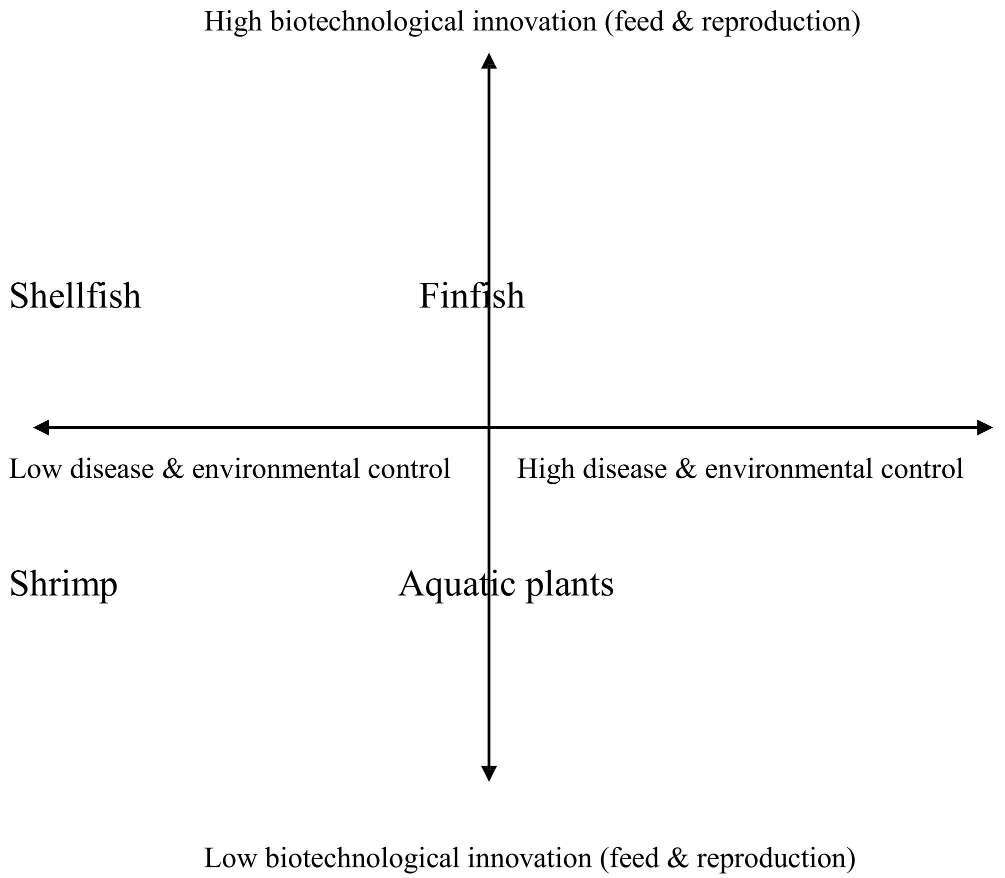

Figure 2. Scenario Matrix

a. Shrimp Scenario

Low biotechnological innovation, low disease and environmental control.

This shrimp scenario explores the possible outcome of a situation in which aquaculture is practiced currently within the confines of present knowledge and technology. Fishmeal continues to be the primary protein source in fish feed, the reproduction of preferred species such as cod, tuna, eel continues to be a bottleneck.

In the field of disease control, not much has been achieved, disease outbreaks are rampant and antibiotics have failed to protect culture fish from disease outbreaks due to antibiotic resistance. Environmentally, aquaculture continues to pollution aquatic environment, the wild harvest of fingerlings and the destruction of mangroves to establish shrimp ponds continues unabated with serious effects on the recruitment of natural fish stocks, erosion of costal areas and acidification problem.

The shrimp scenario is therefore one of doom, where aquaculture activities, which fails to take proper care of the environment in which it operates as well as evolve sustainable technologies will eventually become a backlash on its viability and sustainability.

b. Aquatic plants Scenario

Low biotechnological innovation, high disease and environmental control.
The aquatic plants scenario portrays a situation where not much has been achieved biotechnologically to de-emphasize the dependence of aquaculture on fishmeal. As a result, fishmeal continues to be the primary protein source in fish feed. The reproduction of preferred species such as cod, tuna, eel continue to be a bottleneck.
Advances in vaccine technology in combination with other preventive disease control measures such as the use of probiotics to suppress the proliferation of harmful bacteria and viruses have enable a greater control of disease outbreaks. The use of immune-stimulants to prop the immune system of culture fish against noxious microorganisms has to prevent disease outbreaks or keet their occurrence to the minimum. Strict adherence to environmental regulations governing cage aquaculture operations have succeeded in minimizing the polluting effects of cage aquaculture.
However, fishmeal continues to be used and the wild capture of fingerlings of species whose reproduction continues to pose a problem is ongoing, the environmental impacts of aquaculture on wild fish populations have reached a disturbing stage.

The aquatic plants scenario is therefore an unhealthy development since advances made in the field is one-sided. It can be likened to the current state of development of salmon aquaculture, *i.e.,* high reproductive success but continues to pollute the environment due to its continuous use of fishmeal and its escapee problems.

c. Shellfish Scenario

High biotechnological innovation, Low disease and environmental control

The shellfish scenario envisages the situation where there is high biotechnological advancement that has unravelled the feed and reproduction bottleneck. Fishmeal is no longer the primary source of protein in fish feeds. It has been totally replaced with alternatives such as plant proteins and single cell proteins from microorganisms cultured cheaply with agro-processing wastes. The artificial reproduction of hitherto difficult to reproduce species such as the eel, cod and coral reef species has been successfully achieved. The pressure on wild fish stocks does not exist any more. No seed collection from the wild and no threat to biodiversity.

However, earlier reliance on antibiotics and other chemical agents for disease control has resulted in the emergence of resistant and virulent viruses and bacteria. The consequence of this is frequent outbreaks of disease with no remedy to curb their spread. The low water quality also facilitates the spread of diseases.
In view of the high disease levels and low water quality, only hardy and disease resistant species such as catfish could be successfully farmed in the polluted waters. Species that require high water quality for survival have all been eliminated.

The shellfish scenario is also a reflection of a lopsided development that will in the long-term result in the creation of a culture environment conducive to the growth of species that feed low on food chain.

d. Finfish Scenario
High biotechnological innovation, high disease and environmental control

The finfish scenario explores the situation where both biotechnological innovations and disease & environmental control are highly advanced and are moving at the same pace. Aquaculture is riding high, all the cultured species can be reproduced artificially and many new species have been domesticated. All life cycle of all aquaculture species can be completed in captivity. Fishmeal has been totally and completely replaces from fish feed formulations. All protein sources are either from plant and microorganisms or are synthesized chemically.
This has enabled the farming of highly preferred and piscivorous species such as the tuna. Tuna can now be reproduced artificially and grow out is no longer a problem since a cheap source protein is available to feed this highly carnivorous species.

Environmentally, recirculation systems has advanced to such an extent that the system treats all of its soluble wastes. The solid wastes are converted to usable microorganism in bio-rectors incorporated in the system. The microorganisms are channelled back into the system as feed for the cultured fish such that nothing is wasted.

Cage culture in bays and near shores have been revolutionized such that the system treats its waste by collecting uneaten feed and faeces from the bottom of the cage and passes it through a treatment bio-rector included in the cage design. As a result of these advances disease outbreaks are absent. Disease control is further enhanced by the use of immune-stimulants, probiotics and vaccinations.

The overall effect is that aquaculture is a net producer of high quality fish for human consumption as well as operates and creates a cleaner environment for other aquatic species to thrive and survive.

4. CONCLUSIONS AND RECOMMENDATIONS

The past two decades have seen the growth of the aquaculture industry from an experimental/pilot stage to a fully grown important sub-sector. Long-term growth of the aquaculture industry depends on both ecologically sound practices and sustainable resource management. Governments can encourage such practices by stringently regulating the creation of new farming facilities in mangroves and other coastal wetlands, establishing fines to minimise escapes of fish from aquaculture pens, enforcing strict disease control measures for the movement of stock, and mandating effluent treatment and in-pond recirculation of wastewater. Despite significant improvements in the industry, many ecologically sound technologies remain on shelf. This is an arena where external-funding agencies such as development banks can play a strategic role by encouraging the development and financing the implementation of sustainable aquaculture technologies, the rehabilitation of ecosystems degraded by aquaculture, and the protection of coastal ecosystems. We therefore recommend that governmental and development organizations, as well as the aquaculture industry and all its stakeholders promote farming of herbivorous and omnivorous species; reduction and replacement of fish meal and fish oil inputs in feed; development of integrated farming systems that use multiple species to reduce costs and wastes and increase productivity.

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