

---

# Investment, insurance and risk management for aquaculture development

## Expert Panel Review 2.3

**Clem Tisdell<sup>1</sup>\*, Nathanael Hishamunda<sup>2</sup>, Raymon van Anrooy<sup>3</sup>, Tipparat Pongthanapanich<sup>4</sup> and Maroti Arjuna Upare<sup>5</sup>**

<sup>1</sup> School of Economics, The University of Queensland 4072, Brisbane, Australia.

E-mail: c.tisdell@uq.edu.au;

<sup>2</sup> Department of Fisheries and Aquaculture, Food and Agriculture Organization of the UN, Rome, Italy.

E-mail: Nathanael.hishamunda@fao.org;

<sup>3</sup> FAO Sub-Regional Office for Latin America and the Caribbean, 2nd Floor, United Nations House, Marine Gardens, Hastings, Christ Church, Barbados. E-mail: Raymon.vanaroo@fao.org;

<sup>4</sup> Faculty of Economics, Kasetsart University, Jatujak 10900, Bangkok, Thailand.

E-mail: Tipparat2002@gmail.com;

<sup>5</sup> Consultant, A-502 Anant Apts, Thakur Complex, Kandivili East, Mumbai-400101, India.

E-mail: u\_maroti@hotmail.com

**Tisdell, C., Hishamunda, N., van Anrooy, R., Pongthanapanich, T. & Upare, M.A.** 2012. Investment, insurance and risk management for aquaculture development. In R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan & P. Sorgeloos, eds. *Farming the Waters for People and Food*. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010. pp. 303–333. FAO, Rome and NACA, Bangkok.

## Abstract

*The Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* stressed that adequate investment in aquaculture is essential for its future development. It identifies several constraints on this investment and makes recommendations for addressing the issues involved. For example, it recognizes the risk and uncertainty associated with returns from investment in aquaculture to be an important constraint on aquaculture investment. This is particularly so because insurance markets only provide very limited coverage for aquaculturists. Since 2000, research has been undertaken by the Food and Agriculture Organization of the United Nations (FAO) to address many of the issues raised in the Bangkok Declaration. This process has not been straightforward because most of the objectives for investment in aquaculture set out in this declaration are indicative rather than operational. In addition, some constraints which are not mentioned in the Bangkok Declaration have started to seriously impede aquaculture development. Economic growth generally and the expansion of aquaculture itself have resulted in increased scarcity of resources vital for the

---

\* Corresponding author: c.tisdell@uq.edu.au

growth of aquaculture. For example, water has become scarcer, available new sites for aquaculture are becoming more difficult to obtain, and environmental and ecological problems of consequence for aquaculture have magnified. As a result of the latter aspect, greater regulation of economic activity, including aquaculture production is occurring. These growing problems appear to have resulted in a decline in the rate of growth of aquaculture production and are associated with a slight decline in the global per capita availability of fish. This poses new challenges for investment in aquaculture and its future growth. The future development of aquaculture is likely to depend more on the intensification of production and less on its extension than in the past. Furthermore, the future development of aquaculture is expected to become more dependent on advances in science and technology than in the past and therefore, investment in science and technology and its application to aquaculture will be of growing importance.

High levels of exposure to risk and uncertainty in aquaculture also continue to restrict investment and stunt aquaculture development. Attention is therefore given to identifying the factors that contribute to risk and uncertainty in aquaculture and methods of specifying the risk and uncertainty involved. The latter should be done by taking into account the consequences of these methods for decision-making by aquafarmers. Alternative methods of managing and coping with risk are outlined and particular attention is given to insurance of assets as a way to cope with risk in aquaculture. Ways of extending the availability of insurance cover for aquafarmers are outlined. It is found that limited practical scope exists for the extension of insurance markets in aquaculture, although with economic development it is likely that extension will occur naturally. This means that most aquafarmers will have to rely on other means to manage and cope with risk and uncertainty.

**KEY WORDS:** *Aquaculture, Insurance, Investment, Risk management, Sustainable aquaculture.*

## Introduction

After a period of rapid expansion, the growth of aquaculture production has tapered off according to findings of the Food and Agriculture Organization of the United Nations (FAO, 2009). Probably, the most important reason for this is that vital resources needed for aquaculture production have become scarcer as a result of continuing global economic growth and a greater volume of aquaculture production. One possible way to counteract this trend is by increased and improved targeting of investment in aquaculture. *The Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* (NACA/FAO, 2001) recognized the vital role played by investment in aquaculture development, but at that time the decline in the growth rate of aquaculture output was not apparent. Now that it is clear, the development of sound strategies for investment in

aquaculture and for ameliorating constraints on that investment have become more important.

There are both critical constraints on investment in aquaculture (such as growing resource scarcity) and continuing constraints which have been evident for a long while. The latter include the riskiness of aquaculture as an economic activity and the difficulties which individual aquafarmers face in managing and limiting their risks. For example, there is little availability of insurance for aquaculture, and where insurance is available, it can be costly, not only because of the high level of risks to be covered but also because of the transaction costs involved in drawing up insurance policies, and the costs of monitoring risks and of processing claims. This restricts the scope that individual aquafarmers have for reducing their exposure to risks. Nevertheless, insurance is not the only potential means available to aquafarmers to reduce their exposure to risks. Therefore, in order to stimulate the development of aquaculture, a variety of mechanisms (including insurance mechanisms) need to be identified that can efficiently reduce the risks experienced by aquaculturists.

The purpose of this paper is twofold: in the light of *The Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* (NACA/FAO, 2001), (i) to assess advances in facilitating investment in aquaculture and remaining obstacles to such investment and (ii) to provide background on progress in the management of risk in aquaculture, to identify factors that are a source of risk and uncertainty in aquaculture, to consider the consequences of these risks for investment in aquaculture, to consider different ways of managing risks in aquaculture and in particular, to explore insurance of assets in aquaculture as a way of coping with risk. In considering the last topic, reasons for the slow development of insurance markets in aquaculture will be considered, as well as proposals for stimulating the development of these markets in an economical manner. In addition, other public policies that may be adopted to reduce the risks experienced by aquafarmers and thereby, stimulate the development of aquaculture are outlined and assessed.

## **Progress with strategies for investment, insurance and risk management for aquaculture development**

*The Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000* (NACA/FAO, 2001, Part V) emphasized the importance of investment both by the private and public sectors for the continued growth of aquaculture and highlighted several strategies that could be adopted to stimulate social investment in the aquaculture sector. The initiatives suggested included the establishment of “credit schemes that support sustainable aquaculture e.g. micro-credit programmes particularly for small-scale development” (NACA/FAO, 2001, p. 466). This document also mentions that “the level of risk is important when supporting initiatives to address poverty alleviation” (NACA/FAO, 2001,

p. 466). In fact, as discussed in this review, the amount of credit available to aquaculturists is limited by the considerable amount of risk which they face in their economic activities. However, the Bangkok Declaration recognizes that risk is just one of the factors that restrict investment in aquaculture and therefore, the development of aquaculture.

The FAO has produced several documents since 2000 in order to help develop strategies that will foster aquaculture development. In relation to insurance and risk management for aquaculture, these include *The review of the current state of world aquaculture insurance* (Van Anrooy et al., 2006), *Guidelines to meet insurance and other risk management needs in developing aquaculture in Asia* (Secretan et al., 2007), and *Understanding and applying risk analysis in aquaculture* (Bondad-Reantaso, Arthur and Subasinghe, 2008). In addition, *Microfinance in fisheries and aquaculture: guidelines and case studies* provides a thorough review of microfinance for fisheries and aquaculture, livelihood and micro-enterprise development opportunities for women in coastal fishing communities in India (Tietze, et al., 2007) and lists guidelines and general principles to assist those wanting to “supply microfinance services to aquaculture and for those who intend to include fishing and fish farming communities as part of the client base of their operations” (Tietze and Villareal, 2003).

*The state of the world fisheries and aquaculture 2008* (FAO, 2009) pays particular attention in Part 4 to constraints on growth in the aquaculture sector and consequently, the outlook for aquaculture. It finds that while aquaculture production has grown rapidly in the last few decades, the rate of increase in its volume of production has begun to slow. This report identifies a number of factors that are contributing to this deceleration in aquaculture’s growth. These include constraints caused by the limited availability of natural resources suitable for aquaculture as well as institutional constraints. Knowledge constraints are also mentioned as limiting factors, although little consideration is given to risk and uncertainty as a factor restricting investment in aquaculture and its development. It is however, clear from this report that a combination of factors are starting to limit the rate of growth of aquaculture production. Progress in facilitating investment in aquaculture strategies to alleviate constraints on investment in aquaculture is given detailed consideration in the next section. Subsequently, risk, uncertainty and the availability of insurance markets for aquaculture are the main focus of attention because they have important implications for the amount and nature of investment in aquaculture, its development and the welfare of aquafarmers as was stressed in the Bangkok Declaration.

Research by the FAO has also identified the risk and uncertainty involved in aquaculture activities as a significant constraint on investment in aquaculture and thus, the growth of the aquaculture sector. Several papers have been produced by the FAO that throw light on the extent of this problem and the shortcomings of existing social mechanisms (such as the availability of insurance for

aquaculture) in alleviating this constraint on investment in aquaculture. Specific measures and methods that could be effective in overcoming or reducing the constraints which the presence of risk and uncertainty impose on aquaculture development have also been identified in FAO papers produced since 2000. Nevertheless, while there has been considerable progress in this matter, there is still much more to be done. The analysis of risk and uncertainty in aquaculture is a complex one, as is the development of workable procedures to moderate or allow for this risk and uncertainty in an optimal manner. This is mainly because a wide range of factors must be taken into account in addressing risk and uncertainty, as will be evident from this paper.

## Objectives for investment in aquaculture contained in the bangkok declaration

### What broad objectives should be pursued in investing in aquaculture?

Section 3.7 of the *Bangkok Declaration and Strategy for Aquaculture Development* sets out several objectives that should, according to the opinion of those framing it, be kept in mind when investing in aquaculture. This section mentions several general factors that should be considered when investing in aquaculture. These include sustainability, the desirability of good management, efficiency and poverty alleviation. However, the statement of such objectives is indicative rather than operational in nature. This is so for several reasons. For example, it is not made clear for whom (for which stakeholders) the objectives are desirable and whether they are considered desirable from the point of view of the aquaculture sector or from the viewpoint of society or communities as a whole. In addition, there are some other operational limitations to the way in which the objectives are framed.

For example, while sustainability may be desirable, it is necessary to specify what should be sustained and why (Tisdell, 2009b, Ch.7). Sustaining some phenomena can be undesirable. It is mentioned in Section 3.7 of the Bangkok Declaration that it is desirable to sustain aquaculture livelihoods. This may be so, but it need not always be the case. As conditions change, it is sometimes optimal for aquafarmers to exit aquaculture and take up other occupations. In such cases, adjustment of aquaculturists to altering conditions becomes an issue. More progress is needed in specifying what should be sustained in relation to aquaculture, what should not be sustained, and the extent to which the conditions for aquaculture are sustainable. Secondly it is not absolutely clear what constitutes good management in aquaculture. Although the FAO has given attention to this matter (see Secretan *et al.*, 2007), the issue is not completely resolved.

Thirdly, more precision is needed in defining what constitutes an efficient aquaculture sector. A complex set of issues are involved in dealing with this

matter. This is clear if the usual approach of economists to defining economic efficiency is adopted (see, for example, Tisdell and Hartley, 2008, Ch.2). Economists consider an economy to be efficient if it is organized in a way ensuring that its limited resources are used to minimize scarcity; that is, to satisfy human wants to the fullest extent possible given the limited availability of resources. It is usually argued that this requires productive units to exhibit technical and managerial efficiency and that resources be distributed between their alternative uses so that allocative efficiency is achieved. All of these factors are relevant when assessing the economic efficiency of aquaculture from a social point of view. However, social evaluation is even more complex because economic and other systems do not remain stationary but are perpetually changing; and the actions of human beings influence this change. Furthermore, social evaluation of possibilities does not depend on economic efficiency considerations alone.

Because human beings can and do alter economic systems as a result of research, the discovery of new techniques of production and new commodities, and innovation, systems that ensure allocative efficiency may, as pointed out by Schumpeter (1954), fail to minimize economic scarcity in the long run because they may not ensure “dynamic efficiency”, that is as much economic growth as desired. Therefore, it is apparent that what is efficient can be quite complex. The importance of strategies to invest in research and development for the advancement of aquaculture is stressed in Section 3.2 of the Bangkok Declaration, and it will be argued later that this investment is of increasing importance if increases in aquaculture production are to be sustained and falling per capita availability of fish and other aquatic products is to be avoided. Scientific research needs to be accompanied by effective development, application and diffusion of the results obtained to aquaculturists. Section 3.3 of the Bangkok Declaration outlines means for doing this.

Careful reading of Section 3.7 of the Bangkok Declaration indicates that those framing it believed that multiple objectives should be pursued in investing in aquaculture. While this may be desirable, the adoption of multiple goals also can encounter operational problems. For example, it may be impossible to satisfy all the multiple objectives simultaneously. If so, what trade-offs should be made? For example, the goal of immediately alleviating poverty could in some cases conflict with economic efficiency or economic growth goals. Issues involving dynamics need to be taken into account. For instance, should some become rich now and others remain poor in the expectation that (as a result) all will eventually become richer? General objectives for investing in aquaculture as set out in the Bangkok Declaration raise broad issues that have not yet been resolved, and which frankly, it could be difficult or impossible to resolve.

### **Specific recommendations (objectives) for investing in aquaculture**

Several specific recommendations for investing in aquaculture development are set out in Section 3.7 of the Bangkok Declaration. It may be useful to consider the recommendations in the Bangkok Declaration for aquaculture investment in the light of economic criteria. Economists have developed criteria for assessing efficient resource-use and for suggesting circumstances in which government intervention in market systems is likely to increase economic efficiency. They point out that government intervention might be justified if (i) it increases the economic efficiency of the economic system in satisfying wants or (ii) if it improves the distribution of income, for instance, alleviates the incidence of poverty.

The Bangkok Declaration stresses that it is important for public-sector investment to complement private-sector investment in aquaculture if the full benefit of private investment is to be obtained. Public investment in capacity building, the development of institutions and in infrastructure is needed in order to realize potential returns from private investment in aquaculture. Market systems are likely to undersupply these investments because of market failures. Since 2000, transport infrastructure and infrastructure for utilities have developed rapidly in some countries, such as China and India, as a result of public investment. While these investments are not specific to aquaculture, they have assisted aquafarmers by giving them less costly access to markets for their produce and by facilitating their access to some inputs, for instance fish food and energy inputs.

Other specific suggestions in the Bangkok Declaration include:

- (i) Governments should subsidize and facilitate private investments in newly emerging types of aquaculture or aquaculture being started in new situations. In such cases, there are considerable risks, and time is required for aquafarmers to develop their managerial skills. This is a type of infant industry argument. Such intervention is sometimes justifiable on economic grounds, but it is also important that there be good prospects of the new aquaculture activities becoming economically visible in a reasonable period of time so that the subsidy can be discontinued. In other words, there must be reasonable prospects that the infant will grow up and become independent.
- (ii) Continuing public investment in rural and small-scale aquaculture in developing countries, and in applied research and farmer access to knowledge and capital are recommended. This recommendation may be supported on income distribution grounds. Also, while large private enterprises may usefully engage in research and development (R&D) for aquaculture, they are unlikely to focus on innovations of particular value to small-sized producers in developing countries because it is difficult for large enterprises to market new techniques to this group of aquafarmers. There can also be market failure in the access of aquafarmers to knowledge and capital. The limited access of aquafarmers to finance is a major issue and is discussed in later sections of this paper.

- (iii) It is also indicated that the public sector should encourage the private-sector investment in aquaculture projects and infrastructure capable of yielding community-wide benefits from aquaculture, especially to rural communities. Such projects could include processing plants for aquaculture products and cold stores.
- (iv) Another suggestion is that governments develop mechanisms which encourage the growth of environmentally and socially responsible aquaculture. With continuing economic growth, environmental spillovers (externalities) from economic activities (including aquaculture) increase in importance (see, for example, Tisdell, 2003, Chs. 1 and 28). These result in market failures and are the basis for increased government intervention in the market system. These regulations can constrain investment in aquaculture but may be justified on economic efficiency grounds.
- (v) It is recommended that governments give “support to sponsorship of industry-driven codes of practice to promote responsible aquaculture”. Whether industry standards and codes of conduct are the appropriate ones from a social point of view is debatable, but in some circumstances, the setting and enforcement of standards can overcome market failures and stimulate investment in an industry (as, for example, argued by Akerlof, 1970). However, it is often difficult to decide on the optimal standard for a product, and the required standard may vary with income levels.
- (vi) It is also said to be desirable to “establish credit schemes that support sustainable aquaculture, e.g. micro-credit programmes, particularly for small scale development”. The FAO has given particular attention to this aspect since 2000 (see, for example, Tietze and Villareal, 2003).

In addition, the Bangkok Declaration suggests that international donor resources could be more effectively employed than in the past, and that there should be greater awareness among financial institutions and assistance agencies of the contribution aquaculture can make to economic development and poverty alleviation. They should also be more aware of its financial needs.

Note that farmers involved in small-scale aquaculture operations (especially those in developing countries) find it difficult or impossible to obtain credit or finance for aquaculture. Reasons include the relatively high risk involved in such investment, the comparatively high costs involved in transacting small loans and the inability of many aquaculturists to offer adequate collateral to cover their loans. These factors are discussed later. Some of these factors also limit the access of small-sized aquaculturists to insurance. Furthermore, the inability of aquaculturists to obtain insurance adds to the risks encountered by their creditors and lenders and therefore, their disadvantage is reinforced. It should, however, be pointed out that while these factors limit the supply of credit and finance for aquaculture, they also limit the demand of some aquaculturists for credit. Many small-sized aquaculturists want to avoid debt because of the risks involved.



Although this is not mentioned in Section 3.7 of the Bangkok Declaration but referred to in Section 3.2, investment in R&D is of major importance for continuing aquaculture development, and its results are a major driver of investment in the aquaculture sector. Market failure occurs in relation to R&D and in the diffusion of its results (see, for example, Tisdell, 1981, Ch.1). While private industry can find it profitable to undertake some types of R&D and market innovations obtained from it, it does not find it profitable to undertake all R&D that is socially beneficial from an economics point of view. Both private and public-sector participation in R&D and in innovation in aquaculture is socially desirable, and an appropriate balance needs to be maintained between the efforts of these two sectors. It is argued in the next section that recent developments in aquaculture indicate that its future development is likely to become more dependent on scientific and technical progress than in the past.

## **Recent trends in aquaculture development: their implications for investment in aquaculture**

### **Recent trends in aquaculture production**

Since 2000, some trends (highlighted by FAO, 2009) in aquaculture production have become apparent which would not have been obvious when the Bangkok Declaration was drawn up. These trends have important implications for investment in aquaculture. While investment in aquaculture has continued to rise, it has been insufficient to sustain the rate of growth of aquaculture production.

The FAO (2009) estimates that in the period 1995–2005 compared to 1985–1995, the annual growth rate of aquaculture production fell from 11.1 to 7.1 percent. Furthermore, per capita availability of fish globally appears either to be stagnant or slightly declining because supplies from aquaculture are not growing at sufficient pace to more than compensate for lack of growth in the wild catch of fish. It could be argued that one of the reasons why aquaculture production is not growing at sufficient pace to enable increased per capita consumption to be achieved is that there has been insufficient investment in aquaculture. However, as discussed below, investment in aquaculture and returns on this investment face growing obstacles as a result of economic growth.

The FAO finds that the rate of growth in aquaculture production has tapered off both in high-income and low-income countries when each is considered as a group. Geographically, only Africa has shown an increase in aquaculture production. This, however, is mainly in North Africa and is an increase on a low base. Furthermore, the rate of growth of aquaculture production of nearly all groups of species declined in 1995–2005 compared to 1985–1995, production from marine fishes being an important exception (FAO, 2009, p.157).

## **The relationship between these trends and investment in aquaculture plus continuing constraints**

FAO (2009, p. 153) points out:

*“The popular assumption – that aquaculture production will grow as long as demand does, and do so in volumes that will virtually match demand growth – is unfortunate as it sends a surreptitious message that there is a considerable degree of automatism in the expected aquaculture response and, thus, little need for enabling public policies. Such a view of the seafood sector is misleading for those who formulate public policies towards aquaculture and capture fisheries. Aquaculture-enabling policies are essential for the steady and sustainable growth of the sector”.*

It continues by stating that worldwide the rate of growth in aquaculture production is slowing. This appears mainly to be because aquaculture is facing tightening constraints because of increasing scarcity of some of its vital resources. This development poses growing challenges for “public administration that uses public resources to promote continued aquaculture growth” and makes it more difficult (overall) for aquafarmers to add to their productivity and to maintain their returns by undertaking extra investment in aquaculture.

An important influence on this trend is the operation of the law of eventually diminishing marginal productivity or diminishing marginal returns (see Tisdell, 1972, Ch.7). The law of diminishing returns comes into force when some of the required resources for production of commodities (such as aquaculture produce) become limited in availability and/or when this is so for its more productive resources and the expansion of production must increasingly rely on the growing utilization of inferior resources. Industries such as aquaculture and agriculture are increasingly subject to this law. This law operates in the absence of offsetting influences, such as technological and scientific progress, which tend to raise productivity.

In relation to aquaculture, growing resource constraints include the increasing scarcity of the availability of water for aquaculture (due to increased competition between aquafarmers and others for water supplies) and increased competition for the use of land and aquatic space due to economic development.

The expansion of aquaculture was initially driven by both the profitability of its expansion to new areas and its intensification in areas already used for aquaculture. Further extension of aquaculture is becoming more difficult, and the returns on its extension appear to be declining in those areas and fields of aquaculture that are relatively mature. Less scope exists than previously for the areal expansion of aquaculture. Therefore, in the future, there will need to be greater reliance on the intensification of aquaculture to raise its yields. This will call for greater investment in R&D and require more capital-intensive aquaculture. In turn, greater levels of investment will be needed in existing

aquaculture enterprises. Although scope may still exist for the areal expansion of aquaculture in sub-Saharan Africa and Latin America, as suggested in FAO (2009), this expansion will not be without difficulties.

A further constraint on aquaculture growth in developing countries, such as China, which are major producers of aquaculture products is that with their economic development, opportunities of farmers for earning income off-farm are likely to increase. As a result, the availability of rural labour for aquaculture can be expected to decline. To some extent, this might be compensated for by the substitution of capital for labour in aquaculture and by an increase in farm sizes. Clearly, in such cases, the availability of funds for investment in aquaculture is important.

In addition, as a result of economic growth, including the growth of aquaculture itself, several environmental and ecological problems are emerging which are limiting the expansion of aquaculture and the returns obtained from it (see, for example, Tisdell, 2004, 2007, 2009a). Lack of social acceptability towards some forms of aquaculture, particularly site allocation, also inhibits its expansion. Social acceptability is likely to become a growing constraint. While environmental regulations designed to manage such effects may restrict investment in aquaculture in the short run, they are sometimes necessary to maintain its returns on investment in the long run. Environmental and ecological policies can be expected to have a major influence on investment in aquaculture in the future.

Environmental and ecological policies for the regulation of aquaculture need to be balanced, well-designed and based on relevant scientific evidence. Otherwise, they may unnecessarily restrict investment in aquaculture and its growth even when its expansion is socially worthwhile and sustainable. Furthermore, severe environmental restrictions in some countries or regions may result in investment in aquaculture shifting to other countries and regions where it is subject to little or ineffective control. In some instances, this can increase global environmental damage. Clearly, the environmental regulation of aquaculture involves complex considerations. While aquaculture developments should not be allowed to take place without concern for the environment, a balanced approach needs to be adopted when giving weight to environmental considerations. Nevertheless, differences in opinion make it difficult to determine the appropriate balance, such as in the case of restrictions imposed by the Ghanaian Environmental Protection Agency on the use of improved tilapia stocks in Volta Lake (Hynes, 2008). Some individuals believe this is overzealous, whereas others obviously do not. Similar examples can be found elsewhere.

The above outlines important trends and dynamic consequences for future investment in aquaculture. There are also some continuing constraints on investment in aquaculture. These include lack of security of property rights and the riskiness of investment in aquaculture.

When property rights are absent, insecure or limited (e.g. the transferability of property is limited), this adversely affects investment that is based on the use of such property (Tisdell, 2009b, Ch.4). Property may be insecure because it is not backed up by legal title and in some communities, there can be lack of respect for private property. Property rights vary from country to country but are weak in some jurisdictions for sites used for aquaculture. When property rights are weak, this reduces private investment and lowers the suitability of properties as collateral for loans, which further adds to lack of investment. However, there are in addition, many other factors that can be important sources of risk and uncertainty in aquaculture and consequently, can have a negative impact on investment in aquaculture. These are continuing problems which will now be considered.

## Identification of factors contributing to risk and uncertainty in aquaculture

### Shared water resources

Although many forms of agriculture are considered to be quite risky from an economics point of view, it is widely believed that aquaculture is, on the whole, much riskier than agriculture (see for example, Secretan *et al.*, 2007). This is primarily because aquafarmers have only partial control (and in some cases, no control) over important variables that influence their yields. For example, the water that aquafarmers use often has to be shared with others and individual aquafarmers at most only normally have little control over its quality and its availability to them.

Variations (which are often difficult to predict) in the quality of shared water (such as alterations in its temperature, its dissolved oxygen content, its nutrient content and the extent to which it transmits pollutants and diseases) influence the growth rates and survival of many aquacultured species, thereby affecting the productivity of aquaculture. Some of these effects are evidenced by changes in the morbidity and mortality of farmed aqua-stocks. Compared to aquaculture, production in agriculture (and in many other industries) is less influenced by events that are not controlled by individual producers. This is mainly because producers in these industries rely less heavily on the use of shared resources to produce their output.

Of course, not every undertaking in aquaculture depends on the use of shared water resources. Sometimes aquaculture occurs in ponds, each of which belongs to a single farmer. But even in that case, the quality of the water in each separate pond may be subject to fairly unpredictable changes. Where production occurs in tanks and constructed raceways and water supplies are pumped to these, some monitoring of water quality is possible. Where water is being recirculated so that the aquaculture system is relatively closed, scope exists for greater control of water quality, but such intensive systems tend to be costly and are not economically feasible for most aquafarmers.

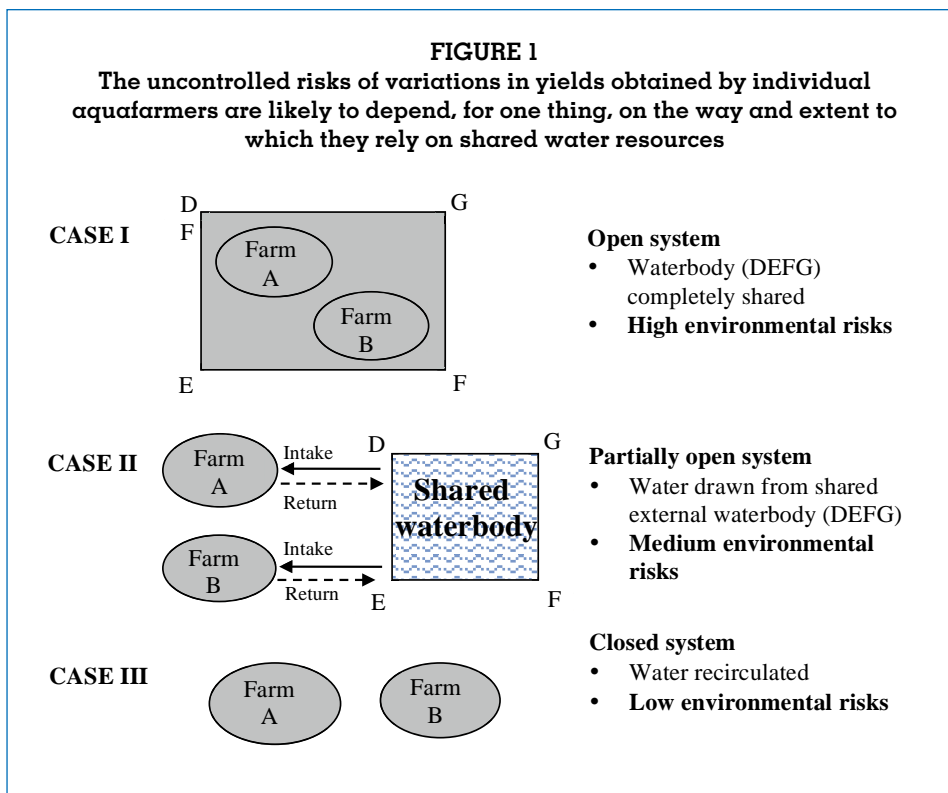
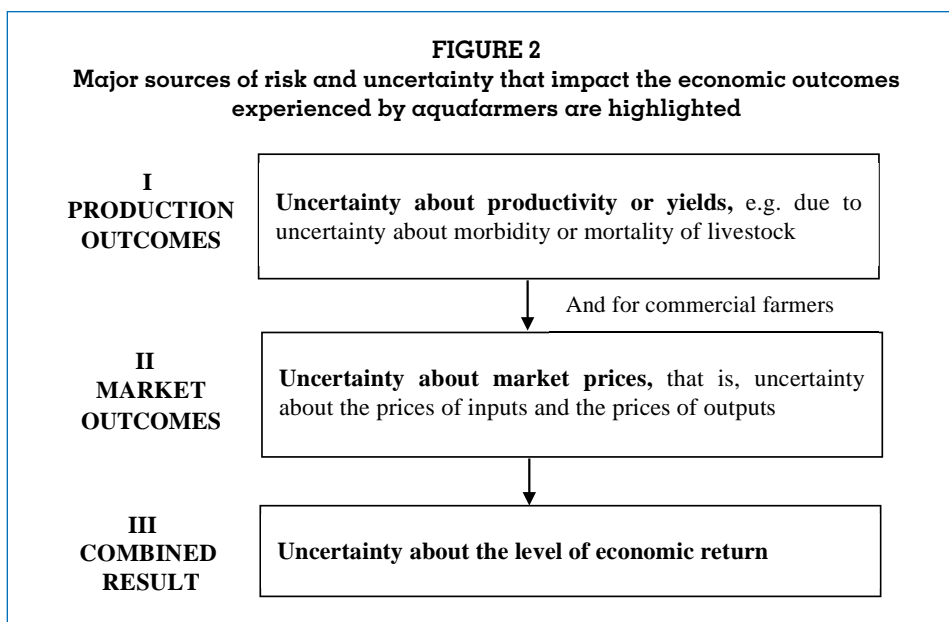


Figure 1 indicates how environmental risks affecting yields in aquaculture vary with the way in which aquafarms depend on external water supplies for the culture of their stock. It is possible that as aquaculture becomes more intensive that the degree of control that aquafarmers are able to exert on their yields will increase.

### Market conditions

If an aquaculture enterprise is market-oriented, it also faces risks associated with variations in its market conditions, i.e. uncertainty about changes in the price of its product or of alterations in the price of its purchased inputs. Whether this source of uncertainty is greater in aquaculture markets than in other types of markets, such as in agricultural markets, is not known; but it is a matter that could be investigated.

The extent of uncertainty about economic returns from aquaculture is the combined result of uncertainty about yields and market prices. Figure 2 highlights this. While all the risk elements shown in Figure 2 apply to market-oriented aquafarmers, only uncertainty about production outcomes is relevant to subsistence aquafarmers who do not trade.



## Specifying the extent of risk in aquaculture and the consequences of risk for decision-making

### Risk specification

The extent to which and how the lack of certainty about important variables affecting aquaculture outcomes can be specified quantitatively varies according to circumstances. For some variables, it may be possible to specify a probability distribution with a reasonable degree of accuracy, but sometimes this is not possible. If uncertainty is considerable, it may only be possible to specify outcomes (and possible payoffs) that may occur but not the probabilities of these outcomes. Intermediate cases are also possible. For example, it may be possible to specify the probabilities of some events occurring but not all.

If reasonably accurate probability distribution for relevant variables can be specified, then use can be made of statistical analysis to derive the relevant consequences of aquaculture decisions. One, however, needs to consider whether the probability distributions are based on objective probabilities, such as empirically based relative frequencies, or on subjective or personal probabilities, for example, those suggested by an “expert”.

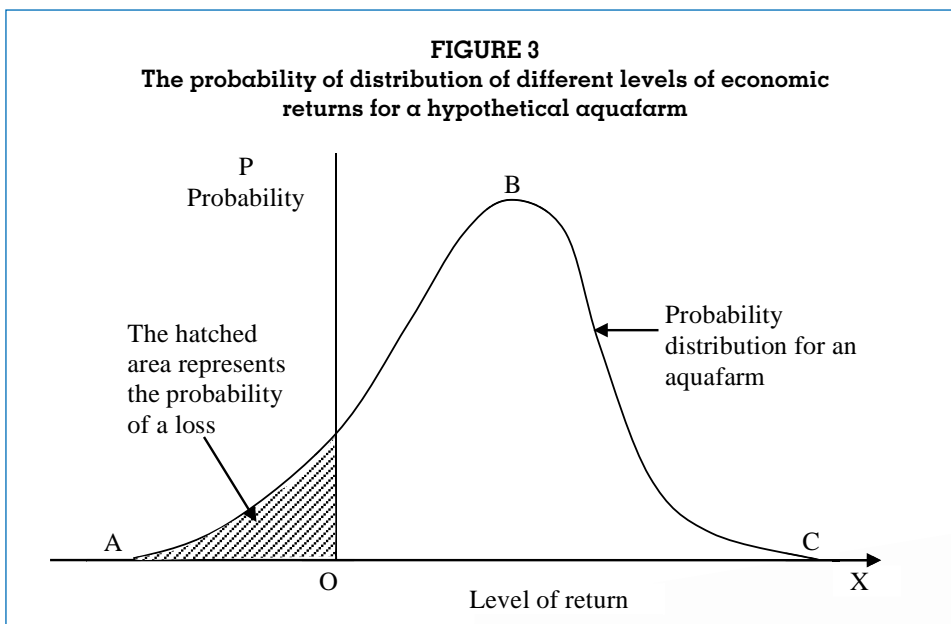
It can be very difficult to obtain empirically derived probabilities for some variables affecting aquaculture because their probability distributions are not stationary. Nevertheless, the longer an aquaculture industry has existed and therefore, the greater its experience with it, the more reliable are likely to be the estimates of its relevant probability distributions.

When a reliable probability distribution of returns for an aquafarm can be obtained, then it is possible to specify the probability that its returns will fall below a specified level, for example the probability that its returns will be negative. For instance, given the bell-shaped probability distribution shown in Figure 3 by the curve ABC, the probability of negative returns is equal to the area of the hatched area shown.

For instance, this probability of distribution can be used to specify the likelihood of the farm incurring a loss. This type of approach has been adopted by Weston, Hardcastle and Davies (2001) to specify the probability of model aquafarms (farming different species) making a loss, and the probability that model aquafarms of different sizes (based on their volume of output) will make a loss when farming the same species. In their modeling, Weston, Hardcastle and Davies (2001) find for most species investigated by them that farms of larger size are less likely to make a loss because of their economies of scale.

Frequently, however, probability distribution cannot be well specified. In such cases, it can be useful for aquafarmers to have information on the sensitivity of their yields and returns to variations in important variables. This information can be catered for by scientists; they can perform sensitivity analysis and communicate the results to farmers.

Information may also be conveyed by specifying outcomes and payoffs for several alternative scenarios that are believed to be possible. Outcomes, and consequently payoffs, are based on assumptions about alternative possible events or states of nature, and this information may be conveyed in matrix form, as in game theory.



Nevertheless, it should be recognized that the process of risk analysis and its application to aquaculture involves several components. The four major components which Arthur (2008) identifies include hazard identification, risk assessment, risk management and risk communication.

It is necessary to determine what the important hazards are in aquaculture, how best to specify the risks involved and their consequences, and in addition, to determine the best ways to manage or cope with these risks. An allied problem is how to communicate effectively to aquafarmers the risks involved in aquaculture activities and the ways in which they can manage these. Advances in information about any of these components can help to reduce the risks faced by aquafarmers.

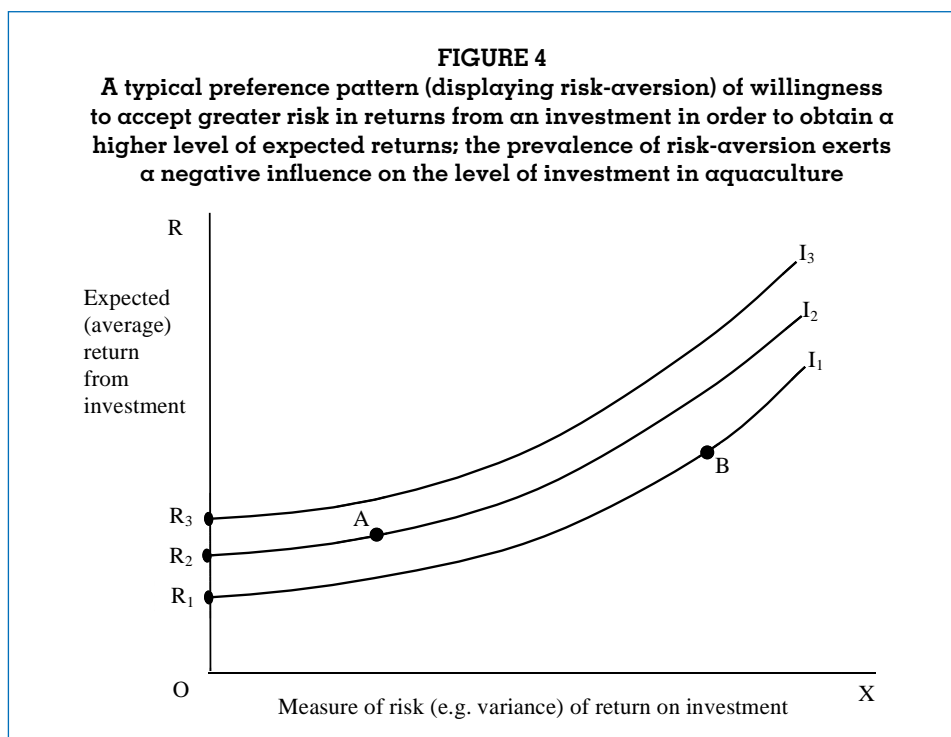
### **Consequences of risk for decision-making: investment in aquaculture**

The nature of decision making when uncertainty exists depends on how well the uncertainties involved can be specified and on the attitude of decision-makers to the bearing of risk and uncertainty. It is believed that most economic decision-makers are risk-averse. The nature and level of risks and uncertainties associated with aquaculture restrict investment in aquaculture and retard the development of aquaculture because of the reasons specified below (see also Tisdell, 2012).

The comparatively high risks associated with aquaculture and problems in obtaining secure collateral for loans and credit, limits investment in aquaculture. Figure 4 illustrates the way in which risk-aversion is detrimental to investment in aquaculture. Suppose a landholder has a choice between an aquaculture project having a level of expected return and risk corresponding to point B in this figure and an alternative agricultural project having a return corresponding to A. Risk-aversion of the landholder is represented by the upward-sloping indifference curves identified by  $I_1$ ,  $I_2$  and  $I_3$ . Risk-and-return possibilities on higher indifference curves are preferred because these give higher returns on average for the same degree of risk. The certainty equivalent returns corresponding to each of the indifference curves shown are respectively  $R_1$ ,  $R_2$  and  $R_3$ . The certainty equivalent return for project A is higher than that for project B. Therefore, the landholder will prefer to invest in project A rather than in project B, even though project B gives a higher expected level of returns; the aquaculture project is not favoured because of its greater risk of loss on return on investment involved for construction of new tanks or ponds.

Income levels also restrict investment in aquaculture. This is because risk-aversion is, as a rule, inversely related to income. Low-income earners are generally more risk-averse than individuals having higher incomes. For instance, many small farmers in developing countries adopt a safety-first approach to investing. This approach may dominate their investment decisions. In particular,





they may only be prepared to undertake investments that result in a very low probability of their income falling below subsistence level. Therefore, they mainly try to avoid risky investments in aquaculture. This attitude contributes to under-investment in aquaculture when the level of investment is assessed from a social perspective.

A further factor that contributes to under-investment in aquaculture from a social point of view is the lack of availability of credit and finance. Lack of suitable collateral compounds the problem. The collateral aquafarmers can offer for loans or credit gives little security to lenders or creditors and makes them reluctant to lend. In many instances, the main asset of aquafarmers is their livestock. The size and value of this stock varies considerably with the passage of time. Thus, it is difficult for lenders to realize the stock in the event of foreclosure. Furthermore, when property rights in land and water spaces used for aquaculture are insecure or absent, this further reduces their collateral for loans.

Another relevant factor is the small size of the farms. The costs of securing collateral in relation to aquaculture are relatively high. The comparative transaction costs involved in arranging loans usually decline with the size of the aquafarm seeking finance. Consequently, there is less availability of finance for those involved in smaller aquaculture operations than in larger ones. In addition, because of their high level of risk-aversion, many small-scale aquafarmers want

to avoid loan commitments. All these factors have adversely affected the level of investment in aquaculture.

It was also observed above that lenders are less knowledgeable about the aquaculture sector than they are about the agriculture sector. Consequently, they can be reluctant to finance aquaculture projects. Similarly government policy can constrain investment and the availability of finance for aquaculture. For example, the failure of governments to provide long-term leases for the use of waterbodies reduces the availability of finance for aquaculture, creates uncertainty and can result in poor environmental practices.

The availability of insurance is another important determinant of investment in aquaculture. When aquafarmers are able to insure their assets, this provides greater security to potential lenders. Nevertheless, as discussed later, there are many obstacles to the development of insurance markets in aquaculture. Several of these obstacles are similar to those experienced by potential lenders to aquafarmers.

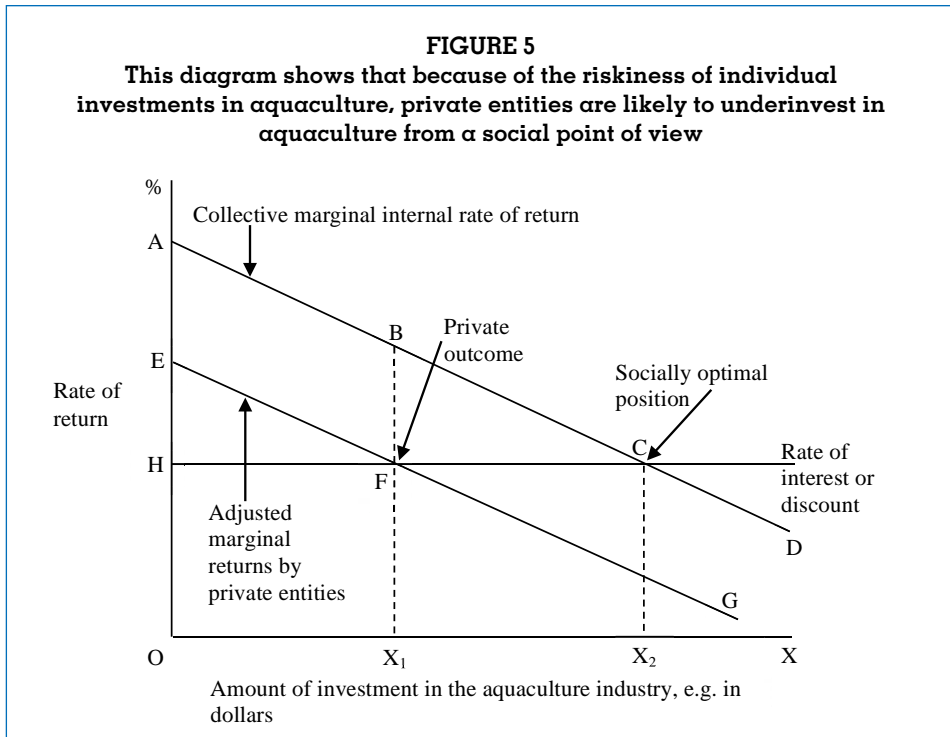
In summary, from a social economic point of view, investment in aquaculture is limited because of the considerable risk involved, and farmers tend to be risk-averse; the collateral that aquafarmers can provide for credit and loans is insecure, which reduces the willingness of creditors and lenders to provide them with credit or loans, and insurance is not available for many aquaculture activities, or they can only be insured at a high cost, which dissuades many aquafarmers from insuring.

## Methods of risk management and investment increase in aquaculture

### Background

When the economic returns from risky investment activities of individual entities in a group are not perfectly correlated, their collective risk is less than the risk experienced by the individuals in this group. This can form a basis for collective risk-sharing, e.g. via insurance. In fact, if the number of individuals is very large, their aggregate returns will show little or no variation if the levels of their individual returns are not correlated. As pointed out by Arrow (1965), the collective gains to society from investment can be increased by expanding the level of investment in industries which exhibit high levels of risk on individual investments but lower levels of collective risk, that is by expanding it compared to the level of investment which would occur under free market conditions. This can be illustrated by Figure 5.

In this figure, line ABCD represents the collective marginal internal rate of return from investment in an aquaculture industry. For simplicity, this is assumed not to be stochastic because of the law of large numbers and lack



of correlation between the returns experienced by individual aquafarmers and their investments. However, because individual aquafarmers do experience risk, they adjust their returns downward to allow for this risk. The internal rates of return on which aquafarmers base their decisions are their certainty equivalent returns; that is, their expected returns adjusted for risk (see Figure 1 and its discussion). Aquafarmers act as if the marginal internal rates of return on investment are as indicated by line EFG.

Assuming that a discount rate (e.g. a rate of interest) of OH exists, aquafarmers will want to invest  $X_1$  in aquaculture. However, from a social point of view, it is optimal to invest  $X_2$  in the industry. This implies that, from a social point of view, there is insufficient investment in the industry. This low level of investment is due to the risks faced by individual aquafarmers. Collective economic returns could be increased by a higher level of investment in aquaculture. Both institutional and non-institutional measures can be used for this purpose.

### **Institutional measures**

Institutional measures that can be used to manage risks in aquaculture include some that are easily altered by government policies and others that are more difficult to change.

Governments can adopt a variety of policies to counteract under-investment in risky aquaculture activities. These include subsidies for investment in

aquaculture; they reduce risk to farmers. However, in assessing the desirability of this approach, there is a need to take account of the costs of administering such a scheme. If these costs are too high, subsidy schemes will not be economic from a social point of view.

Other public policies that could reduce the riskiness experienced by those investing in aquaculture include provision of extension services. By providing aquafarmers or potential aquafarmers with information that reduces their uncertainty or by making aquafarmers aware of management techniques that can reduce their exposure to risk, extension services will counteract underinvestment in aquaculture.

Important institutional features include available forms of ownership of an enterprise, the nature of property rights (including the security of property), the size of the enterprise, the extent of market development and the country's macro-economic development level.

Regarding the forms of ownership, individuals can often reduce their risks by sharing their risks with others. The public company form of ownership, especially when combined with limited liability, can be an effective means of reducing the risks of investors. However, this form of legal entity (a public company) is not usually within reach of small enterprises, be it elsewhere or in aquaculture; sole ownership continues to expose small enterprises to the greatest risk. To reduce these risks, small enterprises can consider the private company limited liability, partnerships and co-operative forms of ownership or self-help microfinance groups.

It is important to emphasize that none of these ownership forms is always an economic option for very low-income enterprises, as is often the case in developing countries. In addition, although the above forms of ownership facilitate risk sharing, they can expose partners to these arrangements to new risks. For example, principal-and-agent problems can arise in the case of public companies. The co-operative forms of ownership may also be cumbersome and can be plagued by free riding by members of the co-operative, but in recent years formation of self-help groups in Asia and providing credit through microfinance have shown encouraging results for developing aquaculture on a small scale.

The nature of property rights is also important in risk management. Greater security of property rights lowers the risks taken by individual investors and in turn, this is likely to improve their credit prospects. Increased security of property rights and a reduction in the costs of enforcing these rights can help stimulate investment. Note that apart from the legal status given to property rights, the social respect that individuals have for such rights is an important consideration and depends on the prevailing morality (ethics) of society.

Full property rights only exist if the possessor of the property has exclusive rights to use it and enjoy its produce, and if the possessor is able to transfer it without impediment (Tisdell, 2009b, pp. 103–104). If others can take the produce of the property, this reduces the benefit obtained by the possessor from investing in the property. If a property cannot be transferred or easily transferred, it is of little value as collateral for loans because investment in it cannot be recouped by its sale. These factors reduce the willingness and ability of possessors of property to invest in it.

The extent of market development influences, among other things, asset leasing possibilities and insurance availability. Leasing of assets provides a means by which aquafarmers can reduce their exposure to risk and to some extent, counteract a shortage of available credit and capital. For example, leasing of equipment or land reduces the extent to which investible funds are locked into an enterprise and lowers the level of possible sunk costs of the aquafarmers should their aquaculture enterprise be unsuccessful. The extent to which leasing arrangements have developed in relation to aquaculture is not well documented. The property rights need to be given for long-term lease, i.e. for the period of loan repayment of 10–15 years.

The development of markets for leasing assets is, in turn, influenced by the institutional arrangements that prevail in society. Taking into account market transaction costs, larger enterprises are more likely to have access to leasing arrangements than smaller ones.

Insurance provides another means of coping with risks in aquaculture. Its availability and costs are influenced by institutional factors and market transaction costs, as well as by the inherent risks faced by the insurer. The availability of insurance for aquaculture activities is very restricted, and it is more likely to be an available option for larger-sized enterprises than for smaller-sized ones (Secretan *et al.*, 2007). Insurance as a means of coping with aquaculture risks will be discussed further in the next section.

The size of the enterprise is important in managing and coping with risks. In general, it is more difficult for smaller-sized aquaculture enterprises to reduce their economic risk than for larger-sized ones to do so. Large aquaculture enterprises spread risks by locating in different geographical areas or through diversification of their products; they are able to average out their risks to some extent. They may also find it more economical to collect information than small-sized enterprises. As discussed earlier, improved knowledge can be used to reduce risk.

A country's macro-economic development level is one of the many other different influences on managing and coping with risk in aquaculture and for which the available methods and the economics of use can vary with the institutional

framework in which aquaculture occurs. For example, aquaculture enterprises with headquarters in higher-income countries may have greater access to mechanisms, such as more secure property rights, to spread their risk than most aquaculture enterprises in lower-income countries. Enterprises originating in higher-income countries are also likely to have greater scope to insure their investments than those based in developing countries. Whether or not they find it easier to be granted limited liability and are more commonly able to spread their risks by company forms of ownership is unknown, but it is probably the case.

Aquaculture enterprises in lower-income countries find it more difficult to reduce their risks than comparable enterprises in higher-income countries, partly because market systems are less developed in low-income countries. Furthermore, because small enterprises dominate aquaculture production in lower income countries, this restricts opportunities to reduce risk in aquaculture in lower-income countries. However, formation of self-help groups can reduce the risk in aquaculture.

### **Non-institutional measures**

There are also several measures that do not rely on the institutional structure of society and which aquafarmers can adopt to cope with risk. These include product diversification and in some instances, the opposite, namely greater specialization in production. They also include retaining flexibility in business operations (e.g. by reducing the use of fixed and sunk capital), limiting their exposure to loans and credit, collecting greater information, engaging in precautionary action, and undertaking well-timed and appropriate remedial actions to limit risks should they emerge. However, all of these measures involve costs that must be weighed against their benefits.

The extent to which the use of these measures is rational involves complex considerations. For example, on the one hand, if the returns from producing different products are not perfectly correlated, product diversification tends to reduce variations in economic returns, which reduces risks. On the other hand, product diversification may result in average returns falling if there are economies from specialization in production. Moreover, product diversification may lead to a general lowering of skills and knowledge about the supply of products produced, and thereby, lends truth to the adage that a “jack-of-all-trades is a master of none”!

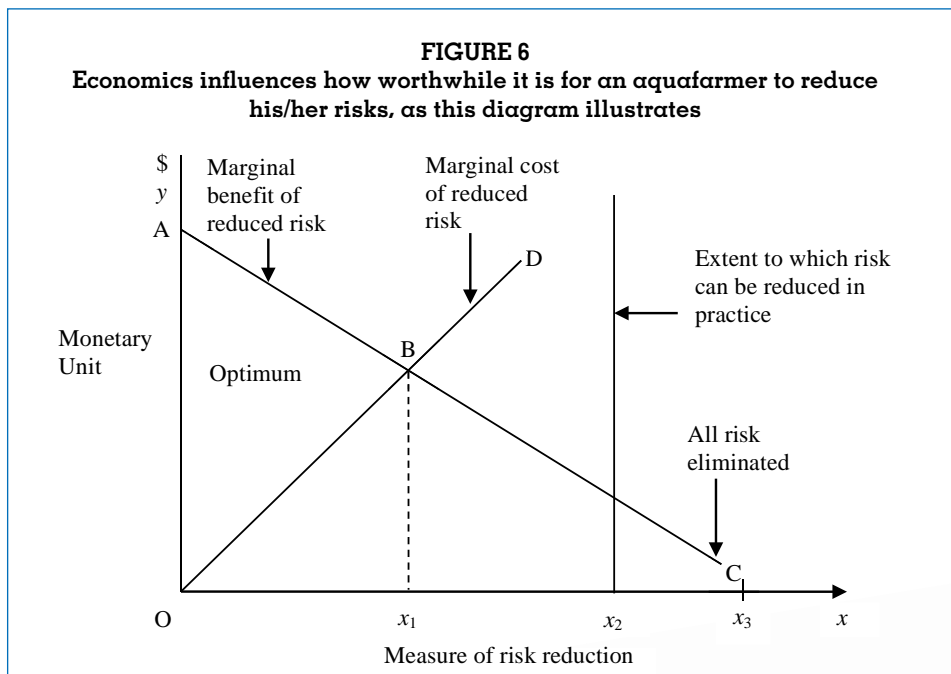
In addition, an aquaculture enterprise can sometimes reduce its risks involved in farming a particular species by specializing in only some stages of its production. For example, some aquafarmers may be able to reduce their production risks by purchasing fingerlings rather than rearing these themselves.

Two of the above mentioned points concerning risk management are worthy of further consideration, namely limits to the economics of risk reduction and decisions to buy-in inputs rather than to produce them in-house.

Economic limits to risk reduction are illustrated by Figure 6. There,  $y$  indicates monetary value (for example, in dollars) and  $x$  is a measure of the extent to which risk can be reduced by an aquafarmer by adopting a relevant action (for example, by buying insurance). The value  $x_3$  corresponds to a situation in which all risk is avoided; but it may be impossible to reach this point. In the case illustrated, the greatest extent to which risk can be reduced is designated by  $x_2$ . The line ABC represents the marginal benefit that the aquafarmer places on risk reduction and the line OBD indicates the marginal cost to the farmer of achieving risk reduction.

In practice, as the risk reduction increases and approaches  $x_2$ , the latter (the marginal cost to the farmer of achieving risk reduction) is likely to escalate. If the fixed or overhead costs of reducing risk are not too high, then the most economic level of risk reduction (in the case illustrated) corresponds to point B, and a reduction in risk of  $x_1$  maximizes the net economic benefit achieved by the aquafarmer from taking action to reduce risk. This highlights the point that risk reduction by an aquafarmer needs to take into account economic considerations. In the case illustrated, it is uneconomic for the aquafarmer to reduce his/her risk to the full extent possible.

Sometimes, it is more economical for governments to adopt measures to reduce the risks experienced by individual aquafarmers than for them to adopt individually measures to reduce their risks. For example, while buying in inputs rather than producing them in-house is an economic option, it can expose the buyer to added



risks. For example, it may be difficult for a buyer to judge the quality of seed or fingerlings, or of purchased feed, and costly for each aquafarmer to carry out the necessary checks. There is a problem of asymmetry of information between buyers and sellers (Van Anrooy *et al.*, 2006, p. v). The seller knows the quality of the product being sold, but it can be difficult for a buyer to judge this quality. In such circumstances, the government may require accurate disclosure by the seller of the characteristics of the product to be sold, and treat serious breaches of this requirement as a criminal offence. However, compliance is not always guaranteed. Alternatively, government bodies or trusted private bodies may test and certify products. These approaches can be more economical than leaving buyers (aquafarmers) to deal individually with this riskiness of quality problem.

There are also other circumstances in which a public approach to risk reduction is more economic than similar action by individuals. For example, it may be more economic for public bodies to collect information (and disseminate it) than for individuals to attempt to gather information. Government action is usually the most economic way to deal with collective risks that can, for example, arise as result of the outbreak of a communicable disease or the introduction of an exotic pest or disease to a country. Government action may be required and can be economic as a means to guard against risks associated with environmental spillovers, such as the possible release of pollutants into waterbodies. All the above-mentioned risks are likely to reduce investment in aquaculture unless they are contained.

Natural disasters are particularly costly to aquaculture. Reducing the risks involved and coping with the aftermath of such disasters requires public preparedness of the type outlined in Westlund *et al.* (2007).

It is safe to conclude that ways of addressing risk and increasing investment in aquaculture are multidimensional and involve complex considerations. As mentioned earlier, insurance provides a potential means for aquafarmers to reduce their exposure to risk. It is, nevertheless, just one possible means by which an aquafarmer can reduce his/her exposure to risk. Furthermore, insurance is not always an ideal means of addressing risk and uncertainty in aquaculture. Let us consider this matter in some detail.

## **Insurance of assets in aquaculture as a way of coping with risk**

### **Lack of insurance markets for aquaculture, especially small-scale, and constraints on their development**

The availability of insurance for aquaculture is limited compared with its availability for other industries and especially so for aquafarmers in developing countries ( Van Anrooy *et al.*, 2006; Secretan *et al.*, 2007). The main reason is the high transaction costs incurred in assessing risks in each individual case,



checking the compliance of aquafarmers with the conditions of an insurance policy and assessing their claims. The risks involved in aquaculture can be relatively unstable, which makes it difficult to determine an appropriate level of insurance premiums.

In order to assess risk, a risk surveyor needs to visit each aquafarm seeking insurance and determine the risks involved and the conditions to be attached to a policy. The comparative expense involved in this is higher for smaller-sized farms than for larger-sized ones. In addition, generally an aquafarmer is expected to report changed environmental conditions that may lead to claims as soon as they emerge (for example, evidence of a disease outbreak in the stock) and to take appropriate defensive action. This may require a visit by an insurance loss adjuster, which adds to the insurer's costs. Furthermore, if a claim is made, on-site assessment of it is usually needed. All these costs tend to be relatively higher for smaller entities buying insurance coverage. It may also be that differences in management practices result, on the average, in the likelihood of claims being higher for smaller-sized aquaculture farms than for larger ones. For example, on smaller farms veterinary services are less affordable than on larger farms.

For these and other reasons, the insurance premium paid by aquafarmers can be expected to increase with the amount of insurance coverage purchased, but at a decreasing rate. In addition to variations in premium levels, deductible levels are often higher for smaller insurance claims. Deductions of 20 to 25 percent of the total stock loss are common. This means that, if available, insurance coverage is likely to be relatively more expensive for smaller-scale than larger-scale aquafarmers. In fact, premiums are likely to be so high that most small-scale aquafarms find insurance uneconomic, particularly insurance of their livestock. For most aquafarmers, their living stock is their major asset.

There are several reasons why it is difficult or often impossible to insure aquatic livestock. First, it can be difficult to estimate the size and value of this asset because it cannot be easily seen. The insurer, therefore, relies on proper stock purchase invoices and proof of reliable stock accounting principles. Secondly, with the passage of time, the amount and value of the stock alters, which should be covered in the stock accounting systems by the registration of daily morbidity, and intermediate harvests of stock. Thirdly, should a loss occur, it can not only be difficult to verify the amount of the loss, but assessment of the loss must be made quickly before the evidence disappears, for example, in the case of dead fish before they decay. Insurance of more permanent assets such as buildings and equipment is easier because the above mentioned problems are usually absent. Local public authorities may require the rapid disposal of dead fish. This is generally carried out by weighing the dead mass and burying the dead fish in a pit. When local authorities manage this disposal process, they can provide the aquafarmer with written evidence of his/her loss. Nevertheless, the worth of this evidence depends on the honesty of those involved in the process.

Exposure to moral hazards in relation to insurance for aquaculture can also be high (Van Anrooy *et al.*, 2006). It can be difficult or costly to determine whether an aquafarmer has complied with all the management conditions incorporated in an insurance contract. Where there is insurance against theft, traceability can also be problematic. In order to reduce their exposure to moral hazard, insurers usually only cover a part of the possible loss of an asset and require its owner to carry some of the risk. In other words, an insurer usually requires co-insurance by the insured. This is reflected in the deductible amount of the policy. Only claims in excess of the deductible amount are subject to the insurer's scrutiny.

The extent to which co-insurance is required normally depends on the extent to which moral hazard and asymmetry of information exist about the risk being covered. Because of the extent of these problems in insurance for aquaculture, the proportionate level of co-insurance required of aquafarmers by insurers is likely to be high. A high level of co-insurance adds to the relative cost of this type of insurance because of the high fixed costs involved in issuing and evaluating these types of insurance policies.

There have been suggestions that groups of small-scale aquafarmers by forming suitable co-operatives might overcome some of the obstacles to their access to insurance. For example, a co-operative may establish administrative and veterinary arrangements for the group which satisfy the expectations of insurers, thereby reducing premiums or the level of deductibles. Furthermore, some of the costs of loss and risk assessment may be borne by the co-operative itself. These groups could have similar functions to those groups formed to facilitate micro-financing.

Two other features of insurance for aquaculture can be noted. Given the importance of asymmetry of information, settlement of claims based on aquaculture policies are dispute-prone. This can add to the cost of insurance for aquafarmers because insurers need to make allowance for the probable costs involved in settlement of disputes about claims. Insurers have an interest in minimizing these costs and therefore, often favour arbitration as a means of dispute resolution rather than recourse to the legal system. Secondly, the extent to which claim dispute problems are likely to occur depends on the prevailing morality and ethics in societies. For example, the greater the degree of honesty, the lower are likely to be the insurance premiums and the level of deductibles. In addition, insurance coverage may be extended to aquafarmers who have integrated veterinary support and who demonstrate that they have reliable stock accounting systems.

### **Hybrid insurance schemes**

Secretan *et al.* (2007) and Van Anrooy *et al.* (2006) provide a valuable introduction to insurance and risk management in aquaculture generally. In particular, Secretan *et al.* (2007) explore the possibilities for cooperation

between commercial insurers, governments and non-governmental organizations (NGOs) as a way to extend the insurance coverage available to aquafarmers and reduce their exposure to risks. At the same time, they identify several important factors that limit the availability of insurance cover to aquafarmers, particularly small-scale aquafarmers. These factors result in seemingly high insurance premiums, but these premiums actually are a product of underlying costs, such as the high market transactions costs involved in arranging and managing insurance for aquaculture.

One of the possible policy innovations explored by Secretan *et al.* (2007) is the introduction of hybrid insurance schemes. They propose that commercial insurers and governments, and possibly NGOs, cooperate to extend the amount of insurance coverage to aquafarmers. Commercial insurers would cover risks for which insurance is commercially viable, with other parties covering risks of social concern but which are not commercially insurable. More specifically, the hybrid approach proposes that “public bodies use their resources to provide social coverage, but on a basis that is coordinated and compatible with the insurance sector’s approach and that follows its information gathering, inspection and survey and loss adjusting processes.”

This approach is suggested as a method likely to reduce insurance transaction costs, extend insurance services to small-scale aquaculture farmers and “decrease and better manage aquaculture-related risks at the farm level”.

While such schemes could be socially attractive, their economic consequences depend upon the form they take. As pointed out in Secretan *et al.* (2007, p. 5-8), there are numerous ways in which hybrid insurance can be structured between insurers and governments. For more information about this aspect, the reader is referred to Secretan *et al.* (2007). However, it is worth noting that Secretan *et al.* (2007) considers three possible types of hybrid schemes:

1. the government provides coverage (*gratis*) beyond that which commercial insurers are prepared to provide;
2. the government subsidizes the insurance premium to be paid for cover; and
3. the government provides coverage for particular perils (such as floods or typhoons) for which insurers are not prepared to provide coverage.

The extent to which hybrid schemes have developed since they were suggested is unclear. However, before their translation into policy and their implementation, some of their aspects probably need further deliberations. For example, would an aquafarmer be required to have commercial insurance as a precondition for being eligible for the social insurance provided by a hybrid insurance? If so, those aquafarmers who cannot afford commercial insurance or who prefer to cover their own risks may be resentful of their comparatively lower risk cover. Furthermore, hybrid schemes will tend to increase the demand for commercial insurance. In

particular cases, a higher demand for this type of insurance can lead to a part of the economic benefit of the scheme being appropriated by insurers. This is most easily seen on the basis of standard economic theory if it is assumed that the government subsidizes insurance premiums (see, for example, Tisdell and Hartley, 2008, pp. 117–119). On the other hand, if there are strong economies of scale in the provision of commercial insurance, insurance premiums could fall. These theoretical possibilities are explained in Appendix 1. Empirical studies are needed to determine what is likely to occur in practice.

An additional matter requiring consideration is the suggestion that the commercial insurance industry should act as an agent or part agent of the government in assessing social insurance claims. While this can potentially reduce administrative costs involved in the management of hybrid schemes, it raises potential principal-agent issues of the type mentioned, for example, by Williamson (1975). For instance, how are agents from the commercial insurance industry to be compensated for their extra effort in assessing social insurance claims and how is their performance to be monitored.

### **Further discussion of issues involved in insurance and risk management**

One of the economic benefits claimed for hybrid insurance schemes, and insurance generally, is that they promote better management by aquafarmers (Secretan *et al.*, 2007). The main way in which this better management is believed to be achieved is by insurance brokers and insurers placing conditions on the management practices of aquafarmers to enable them to qualify for insurance coverage. While such conditions reduce the risks to the insurer, it is not clear that they necessarily result in better management practices from a social economic point of view. There can be different tests of what constitutes a better management practice, and the relevant tests need to be specified and debated. Also, it needs to be kept in mind that increased insurance coverage and intervention by the insurance industry in aquaculture are not the only possible mechanisms for reducing risk, improving risk management and promoting better management practices (BMPs) in aquaculture. Some of the other possible mechanisms were outlined above. Sometimes increased insurance cover is a more expensive option for reducing exposure to risk than other available alternatives. In any case, the alternatives need to be compared and assessed. When these comparisons are done, it is likely that a combination of mechanisms (in some cases, including insurance) is desirable for risk management in aquaculture.

## **Conclusions**

The level of investment in aquaculture is a critical factor in sustaining growth in aquaculture. Worrying signs have emerged since the Bangkok Declaration of 2000, which emphasized the importance of investment in aquaculture as a

means for its development. Recently, the global per capita availability of fish has declined, and further decline cannot be ruled out. Furthermore, there has been a recent decrease in the rate of growth of aquaculture production. While this could be because the demand for fish has fallen (because for example, red and other meat is being increasingly substituted for fish in countries such as China), this is probably not the main reason. The main reason appears to be that the development of aquaculture is being adversely and increasingly constrained by greater scarcity of vital resources because of its growth and as a result of economic growth in general. The scope for further expansion of aquaculture by its areal extension has become more limited, and its future growth is likely to become increasingly dependent on its intensification and on rises in its capital intensity. Thus, the continuing growth of aquaculture is likely to depend more than ever on adequate levels of investment in it. It will also depend on much more investment being made in R&D for the advancement of aquaculture, the application of research results and the development of infrastructure. Technological and scientific progress can be a powerful force for offsetting declining returns.

Furthermore, risk and uncertainty have been identified as a continuing and major constraint on investments in aquaculture. This restricts the rate of growth of aquaculture production. Because the relative degree of risk and uncertainty is on the whole higher in aquaculture than in other industries and the mechanisms for coping with and counteracting this risk are more restricted than in other industries, there is comparatively under-investment in aquaculture from a social point of view. Investible funds are not allocated in a manner that maximizes the aggregate value of production attainable from the resources used in the economic system. The use of resources is misallocated, given the view that human wants should be satisfied to the maximum extent possible subject to the limited availability of resources.

However, as was discussed, there are many challenges involved in developing mechanisms to rectify this misallocation problem. These challenges exacerbate collective economic scarcity. This is partly because, as was demonstrated in the case of schemes intended to increase insurance coverage in aquaculture, the implementation of mechanisms to solve the problem are themselves not costless and perfect in their operation. This paper has also demonstrated that a multitude of different methods can be used to reduce the impact of risk and uncertainty on the level of investment in aquaculture and that those economic considerations are important in deciding on which mechanism or mixture of mechanisms is appropriate in individual cases. Normally, one would expect a mixture of measures for addressing risk and uncertainty in aquaculture to be appropriate; for example, to be most economic.

## References

- Akerlof, G. 1970. The market for lemons: quality and the market mechanism. *The Quarterly Journal of Economics*, 84, 488–500.
- Arrow, K.J. 1965. *Aspects of the theory of risk-bearing*. Helsinki, The Academic Bookstore, 61 pp.
- Arthur, J. R. 2008. General principles of risk analysis process and its application to aquaculture. In M.G. Bondad-Reantaso, T.R. Arthur & R.P. Subasinghe (eds). *Understanding and applying risk analysis in aquaculture*. FAO Fisheries and Aquaculture Technical Paper No. 496. Rome, FAO. 148 pp.
- Bondad-Reantaso, M.G., Arthur, J.R. & Subasinghe, R.P. 2008. *Understanding and applying risk analysis in aquaculture*. FAO Fisheries and Aquaculture Technical Paper No. 519. Rome. FAO. 304 pp.
- FAO. 2009. *The state of the world fisheries and aquaculture 2008*. Rome, FAO. 176 pp.
- Hynes, J. 2008. Progress in aquaculture development in Ghana. *World Aquaculture*, 39(4): 30–34.
- NACA/FAO. 2000. *Aquaculture development beyond 2000: the Bangkok Declaration and Strategy*. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, C.E. McGladdery & J.R. Arthur, eds. *Conference on Aquaculture in the Third Millennium. Proceedings of the Conference on Aquaculture in the Third Millennium, held in Bangkok, Thailand, 20–25 February. Bangkok*, pp. 463–471. NACA & Rome, FAO.
- Schumpeter, J. 1954. *Capitalism, socialism and democracy*. 4th Edn. London, Allen and Unwin.
- Secretan, P.A.D., Bueno, P.B., Van Anrooy, R., Siar, S.S., Olofsson, A., Bondad-Reantaso, M. & Funge-Smith, S. 2007. *Guidelines to meet insurance and other risk management needs in developing aquaculture in Asia*. FAO Fisheries Technical Paper No. 496. Rome, FAO. 148 pp.
- Tietze, U., Siar, S.V., Marmulla, G. & Van Anrooy, R. 2007. *Credit and microfinance needs in inland capture fisheries development and conservation in Asia*. FAO Fisheries Technical Paper No. 460. Rome, FAO. 138 pp.
- Tietze, U. & Villareal, L.V. 2003. *Microfinance in fisheries and aquaculture: guidelines and case studies*. FAO Fisheries and Aquaculture Technical Paper No. 440. Rome, FAO. 114 pp.
- Tisdell, C.A. 1972. *Microeconomics: theory of economic allocation*. Sydney, John Wiley and Sons. 432 pp.
- Tisdell, C.A. 1981. *Science and technology policy*. London, Chapman and Hall. 232 pp.
- Tisdell, C.A. 2003. *Economics and ecology in agriculture and marine production*. Cheltenham, Edward Elgar Publishing. 384 pp.
- Tisdell, C. 2004. Aquaculture, environmental spillovers and sustainable development: links and policy choices. In M.A. Quaddus & M.A.B. Siddique, eds. *Handbook of sustainable development and planning: studies in modelling and decision support*, pp. 249–268. Cheltenham, Edward Elgar Publishing.

- Tisdell, C.A. 2007. The environment and the selection of aquaculture species and systems: an economic analysis. In P. Leung, C.-S. Lee & P.J. O'Bryen, eds. *Species & system selection for sustainable agriculture*, pp. 57–66. Ames, Blackwell Publishing.
- Tisdell, C.A. 2009a. The economics of fish biodiversity: linkages between aquaculture and fisheries – some perspectives. In K. Ninan, ed. *Conserving and valuing ecosystem services and biodiversity: economic, institutional and social challenges*, pp. 47–57. London, Earthscan.
- Tisdell, C.A. 2009b. *Resource and environmental economics: modern issues and applications*. Singapore, World Scientific. 491 pp.
- Tisdell, C.A. 2012. Economics and marketing. In J. S. Lucas & P. Southgate, eds. *Aquaculture: farming aquatic animals and plants*, pp.252-267. Chichester, UK, Wiley-Blackwell.
- Tisdell, C.A. & Hartley, K. 2008. *Microeconomic policy: a new perspective*. Cheltenham, Edward Elgar Publishing. 457 pp.
- Van Anrooy, R., Secretan, P.A.D., Roberts, R. & Upare, M. 2006. *Review of the current state of world aquaculture insurance*. FAO Fisheries Technical Paper No. 493. Rome, FAO. 92 pp,
- Westlund, L., Poulain, F., Båge, H. & Van Anrooy, R. 2007. *Disaster response and risk management in the fisheries sector*. FAO Fisheries Technical Paper No. 479. Rome, FAO. 56 pp.
- Weston, L., Hardcastle, S. & Davies, L. 2001. *Profitability of selected aquaculture species*. ABARE Research Report 01.3. Canberra, Australian Bureau of Agriculture and Resource Economics. 95 pp.
- Williamson, O.E. 1975. *Markets and hierarchies: analysis and anti-trust implications*. New York, Free Press. 286 pp.

## Appendix I

### **Notes on the economic consequences of subsidizing insurance premiums for aquaculture**

Government subsidization of insurance premiums for aquaculture is a possible way of increasing the insurance cover of aquaculturists. In considering this as an approach to risk reduction experienced by aquafarmers, it is advisable to take into account several factors. These include (1) how responsive is insurance coverage likely to be to the subsidy; (2) who will be the main economic beneficiaries from the subsidy (that is, the incidence of the subsidy); and (3) how much is it likely to cost the government to provide the subsidy. Consider each of these issues in turn.

#### ***Responsiveness of insurance coverage to subsidization of provisions***

In the normal case, some expansion in insurance coverage is to be expected as a result of a subsidy on insurance premiums. The extent of the expansion depends on how responsive the supply of insurance cover and the demand for insurance cover are to a change in the level of premiums. The more responsive is the supply of insurance cover to a higher premium and the greater is the demand for insurance cover to a lower premium, the greater is the increase in insurance cover to be expected as a result of subsidizing insurance premiums, other things held constant.

However, if either the demand for insurance or the supply of insurance (or both) exhibit little response to an alteration in premiums, the subsidy will not be very effective in expanding insurance coverage. In the extreme cases, where the demand for insurance is perfectly inelastic or the supply of coverage is perfectly inelastic, there is no increase in insurance cover as a result of a subsidy.

Thus, in order to know how effective subsidization of insurance premiums for aquaculture (one strategy for implementing hybrid insurance schemes), it is necessary to have empirical evidence on the slope of the supply and demand curves for insurance cover in aquaculture. It is possible that the demand for insurance cover by small-scale aquafarmers is relatively inelastic.

#### ***The incidence or income distribution effects of a subsidy for insurance cover***

It is unlikely that aquafarmers would have their premiums reduced by the full amount of any government subsidy paid on premiums. If the supply and demand curves for insurance cover have normal slopes, the premium to be paid by aquafarmers for coverage will fall by less than the subsidy on premiums and a portion of the subsidy will be appropriated by insurers. The division of the subsidy (the incidence of the subsidy) between aquafarmers and insurers depends on the relative responsiveness of the supply of and demand for insurance cover. For instance, if the demand for insurance cover is less responsive to a reduction



in the insurance premium than is the supply of cover, the major portion of the subsidy will be obtained by aquafarmers.

***The Cost to governments of subsidizing insurance premiums***

Suppose that a government, in order to encourage aquafarmers to insure, pays a fixed percentage of their insurance premiums. Then, other things being held constant, the total cost to the government of this subsidy is larger the more responsive is the demand for aquaculture insurance to a reduction in premiums. Much depends on how a government intends to budget for the payment of its subsidy. If a fixed budget is available for the payment of the subsidy, a larger increase in insurance coverage will be possible if the insurance market is very responsive to a change in premiums than if it is not. In the former case, a smaller amount of subsidy needs to be provided on each policy than in the latter case to bring about the same level of expansion in insurance coverage.

***Concluding comments***

Careful consideration of supply and demand relationships in the relevant insurance market is needed to determine the consequences of hybrid insurance schemes for an expansion in insurance coverage, the distribution of subsidy payments between insurers and the insured and the public finance consequences of these schemes. Of course, apart from the actual costs of the subsidy to be paid by a government for subsidizing insurance cover, it will also have some agency or administrative costs in managing a hybrid insurance scheme. The higher are these costs, the less attractive is this policy from a social point of view.

