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# BIODIVERSITY CONSERVATION: STUDIES IN ITS ECONOMICS AND MANAGEMENT, MAINLY IN YUNNAN, CHINA

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**Alternative Economic Instruments for Regulating Environmental Spillovers from Aquaculture: An Assessment**

**by**

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# Alternative Economic Instruments for Regulating Environmental Spillovers from Aquaculture: An Assessment[1]

**by**

**Clem Tisdell**[2]

**January 1996**



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Research for ACIAR project 40, *Economic impact and rural adjustments to nature conservation (biodiversity) programmes: A case study of Xishuangbanna Dai Autonomous Prefecture, Yunnan, China* is sponsored by the Australian Centre for International Agricultural Research (ACIAR), GPO Box 1571, Canberra, *ACT,* 2601, Australia. The following is a brief outline of the Project

Rural nature reserves can have negative as well as positive spillovers to the local region and policies need to be implemented to maximise the net economic benefits obtained locally. Thus an 'open' approach to the management and development of nature conservation (biodiversity) programmes is needed. The purpose of this study is to concentrate on these economic interconnections for Xishuangbanna National Nature Reserve and their implications for its management, and for rural economic development in the Xishuangbanna Dai Prefecture but with some comparative analysis for other parts of Yunnan

The Project will involve the following:

1. A relevant review relating to China and developing countries generally.
2. Cost-benefit evaluation of protection of the Reserve and/or assessment by other social evaluation techniques.
3. An examination of the growth and characteristics of tourism in and nearby the Reserve and economic opportunities generated by this will be examined.
4. The economics of pest control involving the Reserve will be considered. This involves the problem of pests straying from and into the Reserve, e.g., elephants.
5. The possibilities for limited commercial or subsistence use of the Reserve will be researched.
6. Financing the management of the Reserve will be examined. This will involve considering current sources of finance and patterns of outlays, by management of the Reserve, economic methods for increasing income from the Reserve and financial problems and issues such as degree of dependence on central funding.
7. Pressure to use the resources of the Reserve comes from nearby populations, and from villagers settled in the Reserve. Ways of coping with this problem will be considered.
8. The political economy of decision-making affecting the Reserve will be outlined.

**Commissioned Organization**: University of Queensland

**Collaborator**: Southwest Forestry College, Kunming, Yunnan, China

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# ALTERNATIVE ECONOMIC INSTRUMENTS FOR REGULATING ENVIRONMENTAL SPILLOVERS FROM AQUACULTURE: AN ASSESSMENT


## Abstract

Unfavourable externalities are generated by many social and economic activities. Aquaculture is both a source and a victim of several of these spillovers. Such externalities threaten sustainable development and often are sources of economic inefficiency and market failure. Their control can help to sustain economic development and improve the ability of economies to satisfy human wants. However, economic regulation is not costless and different policy instruments often have different side-effects, some of which may be unwanted. Furthermore, their impact can vary depending on the attribute of production to which they are applied, for example, to inputs, outputs, emissions, etc. Consequently, the assessment of alternative economic instruments for regulating environmental spillovers from aquaculture is much more complicated than some economists and non-economists have led us to believe.

The following alternative policy instruments for the control of spillovers from aquaculture are among those considered:

1. Limits on, or regulation of stocking rates, or densities of fish, or of aquacultured products.
2. Regulation of the nature of inputs to aquaculture, for example, maximum allowable nitrogen and phosphorous content of fish food in Denmark.
3. Taxes on pollutants or emissions from aquaculture farms.
4. Subsidies for pollution reduction.
5. Tradeable pollution or environmental-use permits.
6. Provision of property rights; bargained solutions.
7. Spacing and zoning regulations.
8. Knowledge and information provision.
9. Controls on the use of inputs, such as water and trash fish, the withdrawal of which is capable of causing environmental damage.
10. Prohibition of the use of specified aquaculture techniques or practices.

11. Preservation or conservation orders, for example, preservation of fringing bands of mangroves for natural treatment of wastewater.

In assessing alternative policy instruments for control of spillovers from aquaculture, account must be taken of the comparative agency costs involved in each and limitations on the knowledge available to policy-makers. The relative adaptability of alternative policy instruments to changing circumstances may also need to be considered. These and other factors influence the practicality of using the available alternative policy instruments.

Keywords: Environmental policy; economics\

## 1. Introduction

Unfortunately environmental externalities are generated by many social and economic activities and aquaculture is both a source and a victim of several such spillovers (Tisdell, 1994, 1995; Shang and Tisdell, 1990). Unfavourable externalities threaten sustainable development and are often sources of economic inefficiency and market failure. Their control can help to sustain economies development and improve the ability of economics to satisfy human wants.

This contribution concentrates on assessing the regulation of environmental spillovers from aquaculture bearing in mind that economic regulation is not costless, is likely to be imperfect, and different policy instruments often have divergent side-effects, some of which may be unwanted. Furthermore, the economic impact of environmental regulation is liable to vary with the attribute of production on which the controls are applied. For example, depending upon whether regulations are applied to inputs, outputs or emissions.

In assessing alternative policy instruments for control of spillovers from aquaculture, account must be taken of the comparative agency costs involved in each and limitations on the knowledge available to policy-makers. The relative adaptability of alternative policy instruments to changing circumstances also needs to be considered. As discussed here, these and other factors inf1qence the practicality of using alternative policy instruments to regulate environmental externalities from aquaculture.

An economic system is only fully efficient if the impact of an economic agent's activities on others is fully priced. If this does not occur externalities or spillovers are said to occur. These

unpriced economic effects result in the marginal private net benefits obtained by economic entities from their activities (e.g., marginal profit of aquaculturalists) diverging from the marginal social net benefits of these activities. In all but very exceptional cases (Tisdell, 1993, Chs 3 & 4), this causes economic inefficiency and a loss of economic welfare assuming that economic entities act in their own self-interest to maximise their private welfare.

These externalities can in principle be addressed by policy measures in two general ways:

1. Policy instruments such as emission taxes or trading in pollution rights may be used to price these thereby making them a part of the private costs or benefits of the economic entities involved. Economists describe this as internalising externalities.

2. Prohibitions or limits on environmental use may be imposed. Thus fiat rather than guidance by means of pricing is used to alter private behaviour

Sometimes a combination of pricing and prohibitory methods may be used, for example, a tax on particular types of emissions such as nitrogenous and phosphorous emissions, and a ban on the use of particular chemicals or pharmaceuticals in fish farming.

Within the pricing and prohibitory approaches to regulating environmental spillovers, a variety of policies are possible. These will be discussed after the broad principles of evaluating polices for regulating environmental spillovers in aquaculture are outlined. This is followed by an assessment of these policies and consideration of whether in view of the recent sustainability debate, its necessary from a policy viewpoint to impose restrictions on environmental use in addition to taking account of externalities.

## 2. General Factors to be Taken into Account in Assessing Alternative Policies for Regulating Environmental Spillovers from Aquaculture

Broadly the economic impact of regulating spillovers consists of two parts:

1. those associated with the administration . of the regulations which are sometimes described as agency costs and,

2. consequential economic costs and impacts of the regulations.

Agency costs can also be regarded as a form of transaction costs. Even when private property

solutions of the type suggested by Coase (1960) are adopted with a view to eliminating externalities by negotiation, transaction costs are involved particularly if agreements need to be enforced in the courts.

Policies for regulating environmental spillovers from aquaculture vary in terms of their agency and transaction-type costs and in terms of their consequential economic impacts. Both sets of factors must be taken into account in assessing environmental regulations; a holistic assessment is needed. Table 1 summarises the type of factors to be considered dividing these into agency and transaction-type costs and consequential impacts. Until recently economists tended to concentrate on the latter giving most of their attention to item 12. But with growing interest in institutional economics, and to some extent evolutionary economics, the other items have been getting increasing attention.

**Table 1 Types of agency and transaction costs involved in environmental regulation and the consequential economic impacts of such regulations**

| Policy factor or impact | Comment |
|---|---|
| Agency and associated transaction- type costs | |
| 1. Administrative outlays | Such as salaries for the general staff of the agency. |
| 2. Monitoring or inspection costs | These policing costs can be high. |
| 3. Enforcement costs | These include the legal costs of enforcement. |
| 4. Political capture | The regulated may politically capture or influence the regulators. Regulators may prefer a quiet life and not enforce the regulations rigorously. |
| 5. Bribery | Regulators may take bribes and turn a blind eye to infringements. |
| 6. Imperfect information | Regulators have bounded rationality and thus have to act on imperfect information. Regulations may be inadequately drafted and values of policy instruments may be inappropriate. |
| 7. Adaptability or flexibility of regulations | As economic and environmental conditions change, variations in policy may be necessary. Are the regulations adequate in that regard? |
| 8. Uncertainty of regulations for the regulated | Uncertainty about the rights and obligations of the regulated and about enforcement of regulations may add to the costs of those regulated. |
| Transaction-type costs involved in private-property type of situations | |
| 9. Negotiation costs | Note that many of these costs are similar in nature to those incurred by agencies but they fall on• private individuals in this case. |
| 10. Monitoring, inspection and enforcement costs. | |
| 11. Imperfect information of the parties involved. | |
| Consequential economic impacts | |
| 12. Allocative economic efficiency | To what extent do the regulations improve allocative economic efficiency, for example, bring private marginal cost into line with social marginal cost? |
| 13. Change in income distribution | Different regulations have dissimilar impacts on income distribution. This should be taken into account. |
| Consequences for 'dynamic' efficiency - evolutionary impact | How do the regulations affect technological progress, especially whether they encourage the development of technology for pollution abatement? Do the regulations encourage the development of environmental management skills? |

The use of many methods traditionally recommended by economists for the control of environmental spillovers from economic activities is impractical or uneconomic for several forms of aquaculture. For example, where aquaculture is conducted in a shared water body, emissions from a lease or plot for aquaculture are non- point and can be quite difficult to monitor. Even when aquaculture involves pond cultivation and. water withdrawal from a common body of water with release of wastewater via a point outlet (or a few outlets) effective monitoring of the quality of the water released may be difficult or costly. Where will the water samples be analysed, how quickly, how frequently will they be taken and when? Especially when small-scale scattered aquacultural enterprises are involved, as in some less developed countries, the cost of sampling may be high. There is also likely to be a good chance of the aquaculturalist being able to time their noxious water releases so that they do not coincide with the visit of a pollution control inspector. In some less developed countries, considerable scope in addition exists for bribery given prevailing socio-economic conditions.

Table 2 lists some of the possible adverse environmental spillovers that may arise from aquaculture activities. Methods for controlling these need to be assessed by taking into account the factors listed in Table 1.

**Table 2. Some possible adverse environmental spillovers from aquaculture**

| Policy factor or impact | Comment |
|---|---|
| 1. General subsidence due to use of | This is a problem in Taiwan. Buildings underground aquifers |
| 2. Withdrawal of underground water may reduce the quality of the remaining water. | For example, intrusion of salty water may occur. |
| 3. Brackish water used for aquaculture, for example of shrimp, may seep into underground water and cause it to become saline. | As a result the water may become unfit for human consumption and for agriculture |
| 4. Nitrates and chemicals used in aquaculture can contaminate water bodies. | This can make them unfit for aquaculture, agriculture and human consumption. |
| 5. Clearing of trees and vegetation for, aquaculture, for example, by removal of mangroves for shrimp farms. | Results in coastal erosion in some cases, loss of cleansing function of vegetation, loss of habitat of some commercial species and their recruiting grounds. |
| 6. Spread of diseases and pests. | Aquaculture can accelerate spread of diseases and pests injurious to aquaculture and wild stocks. |
| 7. Competition with the capture fisheries for food | 'Trash' fish caught to produce pelleted food or meal for cultured fish such as eel or Atlantic salmon. |
| 8. Sometimes juveniles or fry of wild stock are captured for culture. | Reduces wild stocks, for example, collection of prawn juveniles in Bangladesh. |
| 9. Conversion to aquaculture farms of habitats used by wild stocks. | Reduction in wild stocks. |
| 10. Loss of recreational space to aquaculture | Can affect swimming, boating and other pursuits. |
| 11. Intrusion of salt into agricultural land from brackish water aquaculture. | Caused by seepage from brackish water ponds. May affect rice land, coconuts etc. |
| 12. Frequent and widespread use of pharmaceuticals, especially antibiotics, may accelerate resistance of disease organisms. | Reduced effectiveness of treatments in aquaculture, possible reduced effectiveness of drugs for human use. |
| 13. Crowding of filter feeders soil as molluscs, crowding or organisms extracting nutrients from shared water columns, for example seaweed. | Reduced yields from aquaculture or smaller specimens of reduced value. Increased risk of disease transmission within aquaculture. |
| 14. Some types of aquaculture produce nutrient-rich wastewater, for example water high in nitrates and phosphorous? | May result in aquatic weed growth, eutrophication, and stimulate red tides. |
| 15. Loss of biodiversity | For example, shrimp farming in Bangladesh is claimed to be causing loss of native fish species (Alauddin & Tisdell, 1996). |

Although possible favourable environmental spillovers from aquaculture are not given attention here, some forms of aquaculture can have positive environmental spillovers and add to sustainability. Fish farming may for example be possible in conjunction with artificial wetlands. Such wetlands have been successfully used to reduce nutrient loads in water-bodies. Polyculture can also be used to lower nutrient loads entering water bodies. In

Calcutta, fish aquaculture is engaged in in ponds and supplied with the city's sewage. Furthermore, when agriculturalists engage in fish culture in farm ponds and dams, they are less likely to use danger us pesticides and chemical fertilizers. Scope exits for expanding the development of aquaculture for beneficial environmental spillovers but more research is needed in that regard. Since aquaculture includes botanic species, they should also be considered. In this respect, note that seaweeds and some molluscs can utilise the nutrients in nutrient rich seawater and so could reduce dangers of red-tide and other unwanted environmental effects.

## 3. Pricing and Market-Making Approaches to Environmental Regulation of Aquaculture

In regulating environmental spillovers from aquaculture, it is important initially to decide which aspect of aquaculture activity is to be controlled to address tile problem. For example, will the control be on the level of production, stocking rates, use of inputs, on emissions of pollutants, on location of activities or on use of particular technologies or farming methods? Depending upon where the controls are applied, they are liable to have different economic consequences. For instance, if the emission of a particular pollutant is the main problem, limitations on aquaculture production levels, or on stocking rates, or on inputs containing the major source of the pollutant will reduce emissions of the pollutant but may fail to encourage development of techniques to reduce its emission. Thus, they may be ineffective in encouraging ‘dynamic’ or evolutionary efficiency. Nevertheless, agency cost, involved in regulating emissions directly may be so high that it is not economical to do this. Thus in Europe stocking rates on fish farms are regulated in some countries and in Denmark the nitrogen and phosphorous content of fish food is limited (New, 1995).

Economists have traditionally favoured pricing and market-making approaches to environmental regulation on the grounds of their allocative efficiency (Tisdell, 1993, Ch. 4). Unfortunately, as will be clear from Table 1, the economic value of a policy cannot be judged solely on its ability to promote allocative efficiency or its consequential economic effects. Furthermore, the simplicity of pricing-type policies tends to be lost when environmental spillovers vary in their economic impact according to their location as is mostly the case in aquaculture.

On the other hand, one should not be too ready to dismiss pricing approaches in favour of

prohibitions. In some cases, very little extra cost is involved in adopting a pricing approach. Since it usually involves the ‘user-pays’ principle, the pricing approach can help fund the administration of regulations and not make this an impost on the general state budget.

Instead for example of setting an upper limit to the stocking rate on aquacultural farms, an alternative is to impose a tax or fee on this rate. The overall fee or charge would be determined to achieve the aggregate rate of environmental impact aimed for. This measure would enable those who find higher stocking rates to be more economical to have these although they would have to pay extra for this. A disadvantage of this method from the point of view of the aquaculture sector is that (at least in the short term) it distributes income away from the sector. Politically, this policy may not be popular from the point of view of the regulated industry. Similarly, instead of regulating the maximum 'nutrient' content of manufactured fish food, one could impose a levy increasing with the nutrient-content of the food.

Pricing and market-making approaches to control of environmental externalities may involve the following:

1. The levying of taxes on economic activities giving rise to environmental spillovers.

2. The payment of subsidies to provide an incentive to reduce or refrain from the above mentioned activity.

3. The marketing of pollution rights or environmental use rights. These may be transferable.

4. Extension of private property rights in an effort to eliminate the externality.

Subsidising pollution reduction is an alternative to taxing pollution creation, and in theory it can achieve the same degree of allocative efficiency. However, in contrast to taxation, subsidisation involves a charge on the state budget. Moreover, it has the opposite income distribution consequences to taxation. It has been argued in the literature (Worrall, 1995) that a subsidy to aquaculture, e.g., for shrimp farming, may be justified because aquaculture is likely to reduce harvesting pressure in the capture fisheries. However, this is a controversial matter; see Tisdell (1991, sec. 6.4)

Marketing of pollution or environmental-use rights has in recent times captured the interest of

many economists. In theory it can have similar allocative and dynamic economic consequences to the methods just mentioned. Nevertheless, actual schemes for marketing such right can vary greatly. For example, depending upon how the rights are distributed, they may bring in little or no revenue for the state or considerable revenue. In this regard compare the policy which allocates initial pollution rights free to existing stakeholders in the industry and allows recipients to market these with the method by which the state auctions or sells rights (available only for one year) taking account of the market. The latter provides the state with revenue whereas the former method does not. Nevertheless, agency costs, sometimes considerable, have to be met when marketing of pollution rights is adopted as a policy.

In the case of aquaculture, many environmental spillovers are site-specific or vary in their consequences according to their location se circumstances uniform rates of taxes, subsidies or prices for rights for environmental-use do not promote economic efficiency (Tietenberg, 1974). Thus extra administrative costs are involved in adjusting them appropriately by regions or locations so reducing their value as regulatory instruments. This is not to say that adjustments are impossible. For example marketed pollution rights may be designated for use in particular regions. However, in this case, it is possible that the market for such rights will become ‘thin’.

As for the suggestion by Coase (1960) that the strengthening of private property rights is likely to eliminate spillovers, this approach is only likely to be a success if the cost of enforcing those rights is low. Unfortunately, in relation to aquaculture, especially if non-point pollution is involved, these (transaction) costs are usually quite high. This limits the scope for private property solutions to environmental problems caused by aquaculture. The nature of most aquaculture is such that 'traditional' economic pricing and market-making approaches to pollution control and environmental use have limited application or can only be imperfectly applied. This is not to say there is no scope for such regulations. They may for example be used in controlling use of underground water. Furthermore, if such methods are used they often have to be modified to suit actual circumstances, e.g., taxes or prices on using the environment may have to be varied according to the locality involved.

## 4. Prohibitions and Administrative-type Regulations

Prohibitive and administrative-type regulations not usually favoured by economists because their allocative and dynamic economic consequences are believed to be less favourable than

pricing and market-making approaches to control of environmental use. However, the comparison is often made ignoring the transaction costs involved in environmental pricing and market-making approaches to control of environmental use. When all costs are taken into account, prohibition and administrative type regulations will sometimes be the most economic means of controlling use of the environment.

The nature of such regulations can vary greatly as does their cost and overall effectiveness. This may take the form of (1) emission standards (2) controls on inputs used in aquaculture (3) on stocking rates (4) preservation orders, e.g., requirements that a certain amount of vegetation such as mangrove cover be retained .and (5) zoning affecting the location and nature of operations of aquaculture farms and other enterprises.

These methods need to be assessed taking account of all the factors listed in Table 1. This means that alternative policies should not be assessed just in terms of their possible consequential economic effect.

Some prohibitions may be costly to enforce whereas others may be relatively inexpensive. For example, it will probably be more costly to monitor compliance with emission standards than to enforce zoning regulations or maximum stocking rates of fish. One has to balance such costs against their contributions otherwise to improving the overall level of economic welfare. In reality a utopian or 'ideal' solution to controlling environmental spillovers from aquaculture is not possible.

## 5. Discussion

Traditional economic approaches to environmental regulation and based on social cost-benefit analysis. Such analysis requires account to be taken of spillovers as well as private net benefits. While it is impossible to go into details here, a major issue raised by social cost-benefit analysis is how to place economic values on the spillovers or externalities which arise. Where there is loss of marketed production or commodities as a result of such spillovers, measuring the economic loss arising from these can be straightforward, in principle. However, in some cases, aquacultural activities can affect the supply of non-marketed goods and the reduction in their supply will need to be valued. Methods such as contingent valuation methods have been developed for this purpose. Nevertheless, they are not without their limitations (Tisdell, 1991, Ch. 9).

Some authors have suggested that because of the uncertainty involved in evaluation of environmental effects that systems of safe minimum standards be adopted (Bishop, 1978, 1979). In some instances, such standards can be combined with the use of transferable pollution rights.

A further modification to the traditional economic approach to environmental regulation has arisen from debate about sustainable economic development. While most parties to the debate agree that externalities need to be taken into account to achieve sustainability, some parties believe that this is insufficient. These individuals argue that strong conditions need to be enforced to achieve economic sustainability.

This group claims that it is now necessary to hold the world's remaining natural resource and environmental stock at approximately current levels (Pearce, 1993). This means that any new economic activity should have a zero net effect on the environmental stock. In relation to aquaculture since an approach may require zero net emissions of pollutants by an aquaculture farm, water recirculation and so on. In other cases, offset policies may be allowed. For example, where an aquacultural development destroys a natural wetland, the developers may be required to establish an artificial wetland, at least equivalent environmentally to the one destroyed. Or artificial -or augmented natural wetlands may be required to be established to help process effluents from aquaculture farms.

New legislation in Queensland, Australia, is intended to force aquaculture farms to have zero net emissions of nitrogen and phosphorous in their waste water. So far, however, this is proving impossible to achieve and more research is needed to develop methods to achieve these standards.

The above leaves open the question of whether such stringent standards are desirable even if they can be physically and biologically achieved. The ad hoc promulgation of such rules can certainly add to economic costs and create- economic inefficiencies. Furthermore, could there not be some circumstances in which nutrient- enrichment of water would to the natural environmental resource stocks?

While economists have traditionally suggested that when environmental spillovers are optimally regulated, some degree of spillover or pollution is likely to be optimal from an economics viewpoint; strong sustainability-advocates often call for a zero net environmental effect. Their main argument is that aggregate stocks of natural environmental capital are now

at critically low levels. Any further reduction is likely to endanger the welfare of future generations.

The argument is continuing. It is one that cannot be ignored by those with an interest in the economics and management of aquaculture and it is already influencing government policies. In many cases, it seems this is happening without the socio-economic consequences and alternative having been fully explored.

## 6. Concluding Comments

A variety of possible policy instruments exist for regulating spillovers from aquaculture but no particular types can be recommended for use in all circumstances. Although economists favour pricing and market-making methods of regulation because of their favourable economic consequences, when all costs are taken into account, there can be circumstances where these methods are not the best available. As a rule one has to select the best amongst imperfect methods of regulation and the appropriate type of regulation or combination of regulations is likely' to vary with the cases requiring attention. For this reason, policy-making in aquaculture cannot be a mechanical affair.

Furthermore, it has become more complicated with growing interest in conditions required for sustainable development. There is still much to be learnt for example about appropriate economic ways to meet strong conditions for sustainability. In addition, continuing importance of environmental assessment and management of aquaculture development and management has been underlined by a recent FAO (1995) publication and by plans of the FAO to follow up with further studies on this aspect.

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