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## Managing water pollution to revitalise the shrimp supply chain in Tam Giang Cau Hai Lagoon, Vietnam

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### Abstract

The area of shrimps farmed in the Tam Giang Cau Hai Lagoon expanded dramatically from 1995 to 2004, but then declined steadily. An exploratory investigation of the shrimp supply chain conducted in 2009 revealed that well-established relational contracts between shrimp farmers and wholesalers had succumbed to environmental risk following persistent and widespread outbreaks of disease in the Lagoon. These outbreaks have been attributed to water pollution, which - in turn - has been linked to the rapid expansion and intensification of shrimp production. While privatisation of the lagoon bed encouraged farmers to adopt more intensive production methods, over-intensification can be attributed to the open access nature of lagoon water, which allows farmers to externalise the cost of their water pollution. This study evaluates a range of pollution abatement instruments against well-known criteria and concludes that transferable quotas for shrimp seed would be the most effective policy instrument given prevailing social, institutional, organisational and political conditions. Even so, the introduction and administration of seed quotas pose major challenges that would require co-management with local user groups.

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### 1. Introduction

Supply chain management is a topic that has attracted the interest of many researchers and practitioners because market competition is no longer between individual firms but between supply chains (Trkman *et al.*, 2007; Li *et al.*, 2005). Food supply chains differ from those in other sectors owing to the perishable nature of

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products and production that is characterised by dependence on natural conditions, seasonality and a lag between production and harvest, all of which make output unpredictable. A food chain evolves within particular social, institutional and natural settings, and individual firms within the chain are exposed to risks facing other firms (Hallikas *et al.*, 2004). These risks may be behavioural (e.g. opportunism) or environmental (e.g. disease, natural disasters, economic shocks and changes in policy or technology) (Trkman & McCormack, 2009). According to Williamson (1996), higher levels of chain coordination help to manage behavioural risk, but coordination becomes more difficult as the level of environmental risk increases.

The area of shrimps farmed in Tam Giang Lagoon expanded at an average rate of 400% each year from 1995 to 2004 (Truong, 2012 p. 53). After peaking at 4,000ha in 2004, the area fell steadily to 2,700ha in 2008 following persistent and widespread outbreaks of disease in the Lagoon. Hop *et al.* (2005) and Thung (2007) conducted experiments that showed some alarming indicators of deteriorating water quality in the Lagoon between 1998 and 2004. These indicators included diminishing levels of diffused oxygen (i.e. an increase of organic pollution) - especially in places close to crowded shrimp farming areas, greater nutrient loads entering the lagoon and less absorptive capacity of the natural environment - conditions conducive to eutrophication, higher levels of total coliform density, and higher levels of organochlorine pesticides in the sediment. Water pollution poses a serious threat to all farmers who raise shrimps in the Lagoon and the resultant yield risk is not only co-variant (i.e. risk that simultaneously affects the vast majority of producers) but also systemic (i.e. it creates risk for other agents in the chain). It is estimated that some 100,000 poor people rely directly on aquaculture and capture fisheries in TGCG Lagoon as their main livelihood activity (Tuyen *et al.*, 2010).

This research addresses three related questions: Why has the quality of TGCH Lagoon water deteriorated so rapidly? How has water pollution impacted on the Lagoon's shrimp supply chain? How can the water pollution problem best be managed? To answer these questions, the authors drew on relevant literature in the fields of institutional economics, supply chain management and environmental economics, conducted an exploratory case study of the TGCH shrimp supply chain, and consulted key informants in local and provincial government authorities to help assess policy options. The paper identifies a set of pollution abatement instruments that could be applied to aquaculture in TGCH Lagoon, and tests them against normative criteria in order to recommend an appropriate policy.

## **2. Why has the Lagoon's water quality deteriorated so rapidly?**

There are several sources of water pollution in the Lagoon including; (i) aquaculture production and other livelihood activities in the lagoon, (ii) agricultural production activities in upstream areas, and (iii) industrial production and urban dwellers in the lagoon catchment. There is no study to date quantifying the respective contribution of each of these sources of pollution. However, aquaculture - and shrimp culture in particular - has been clearly linked to the Lagoon's environmental deterioration (Tuyen, 2002; Huong & Berkes, 2011). Moreover, pollution levels closely tracked the growth of aquaculture. This study focuses only on pollution caused by aquaculture.

In 1993, the Vietnamese government issued Decree 64/CP which allowed households to exercise exclusive rights to certain parts of the lagoon bed in order to practice aquaculture. Demand for secure property rights was strong because export prices for giant tiger shrimps was increasing (FAO, undated) and farmers wanted to protect their investment in shrimp enclosures (Phap *et al.*, 2002 p.30). The Provincial People's Committee responded by issuing Red Book property rights to fixed-gear fishers located near the shoreline who converted their net and fence enclosures into earthen-walled ponds for shrimp production (Huong & Berkes, 2011). Shrimp farmers operating in deeper water further from the shore privatised the lagoon bed by erecting fine-mesh nets. Many of these farmers were allowed to formalise their de facto exclusive rights to the lagoon bed by taking up five-year and one-year permits issued by district and commune authorities respectively (Huong & Berkes, 2011).

However, privatisation related only to the lagoon bed and not to the lagoon water. To emphasise this point, it is useful to distinguish between shrimp farmers who constructed earthen-walled ponds in the shallows of the Lagoon and those operating in deeper water who erected net enclosures to contain their shrimps. When considering net enclosures, it is clear that the water passing through the nets is not a private resource (characterised by exclusive property rights) but rather a common pool resource (characterised by inclusive property rights). Moreover, the use of water to grow shrimps was not governed by the common property rules that regulated the extraction of fish. Like the air above a factory, the lagoon water became an open access resource to farmers producing shrimps in net enclosures. The same argument can be applied to pond farmers if they are able to discharge polluted water into the lagoon. In theory, regulations preventing the discharge of polluted water from shrimp ponds would internalise the cost of pollution to these farmers, encouraging them to adopt cleaner production methods. In practice, it is not cost-effective to police such regulations given the existence of thousands of small and inaccessible ponds.

Unfortunately, the privatisation of Tam Giang Lagoon for shrimp production was not well regulated. Zoning was not implemented and natural waterways were blocked by earthen walls and fine-mesh nets (Tuyen et al., 2010). Pond farmers were not required to construct treatment ponds where polluted water could be cleaned before it was released into the lagoon. Not only did the area used to produce shrimps increase rapidly but farmers also adopted intensive production methods (Huong & Berkes, 2011). The evolving mix of private and open access property rights encouraged shrimp farmers to intensify their production methods as they were able to internalise the benefits of their investment while externalising the cost of their water pollution. In addition, the 'Red Books' issued to many owners improved their ability to finance investments in shrimp farming because formal lenders accepted these certificates as collateral for loans (Xuan & Hoa, 2005; Tinh, 2005). Together, the expansion and intensification of shrimp production elevated the concentration of contaminants (excess feed, shrimp waste and chemicals) over a larger part of the lagoon. In the absence of zoning to keep natural waterways open, it was inevitable that water quality would deteriorate.

### **3. How has water pollution impacted on the Lagoon's shrimp supply chain?**

To answer this question, an exploratory case study was made of the TGCH shrimp supply chain in 2009 focusing on dyadic relationships between agents in the chain. In-depth interviews were conducted with ten shrimp farmers, nine wholesalers - ranging from very small to large in size - three local retailers and the only shrimp processing-exporting company located in Thua Thien Hue Province. The respondents were purposively selected at each stage of the supply chain to ensure variation in the size of transactors and markets served. Themes common to all of the interviews included the development of the respondent's business, its role in the chain, current performance, access to inputs, relationships with input providers, access to customers, and relationships with buyers.

Most farmers purchase shrimp seed on credit from a wholesaler and verbally agree to supply the wholesaler with mature shrimps. These interlinked contracts resulted in fairly strong relationships between farmers and wholesalers while the shrimp industry was growing. While some farmers complained of a hold-up problem created by wholesalers intent on lowering the price once the shrimps had been harvested, and some wholesalers complained that farmers engaged in side-selling to avoid repaying their loans, most of the respondents perceived satisfactory levels of trust in their relational contracts. Farmers did admit to loan defaults but made it clear that they had been unable to repay their loans owing to substantial yield losses following outbreaks of disease. Wholesalers readily acknowledged the problem and stated that yields had become so volatile that they could no longer offer farmers contracts for a specific quantity and quality of shrimp. The supply chain problem was not one of behavioural risk but rather one of environmental risk. Small wholesalers dependent on the local shrimp supplies were forced to reduce the scale of their shrimp business and some quit the industry altogether. Downstream dyads also collapsed with a wholesaler in Thuan An township lamenting that "some processor-exporters who bought shrimps produced in Tam Giang Cau Hai Lagoon now source their shrimps in Quang Tri and Quang Binh Provinces".

The exploratory case study revealed that the TGCH shrimp supply chain was in decline. Both wholesaler and farmer respondents attributed the breakdown of chain relationships to the spread of diseases that caused widespread

losses in production after 2004. Covariant yield risk made it impossible to fulfil supply contracts all along the shrimp supply chain. In short, relationships built on trust and incentive compliant contracts were overwhelmed by heightened environmental risk that was, in part, a consequence of pollution created by over-exploitation of open access lagoon water.

#### **4. How can the Lagoon's water pollution problem best be managed?**

##### *4.1. Policy options to manage pollution caused by aquaculture*

Water pollution would be less of a problem at TGCH Lagoon had the lagoon been zoned and its privatisation regulated to keep natural waterways open. Retrospective zoning will require expropriation of shrimp farms or parts of shrimp farms blocking these waterways. Market related compensation would no doubt help to expedite this process, and so improve the water quality as less waste would accumulate near the shrimp farms and overload the absorptive capacity of the local ecosystem. However, this would not eliminate the pollution and disease problems as farmers will continue to over-utilise the lagoon water while it remains an open access resource.

In theory, pollution could be addressed by imposing physical restrictions on stocking rates, by introducing market-based pollution abatement instruments, or by altering property rights to the lagoon water. Physical restrictions include limits on production (output quotas), on inputs used (input quotas) or on the amount of pollution discharged (pollution permits). Market-based measures refer to instruments like input taxes, output taxes, pollution taxes, tradable output or input quotas, and tradable pollution permits. The environmental outcomes of non-tradable and tradable quotas are the same as they both dictate limits on production. They also entail similar challenges in monitoring and enforcing. However, transferable quotas are expected to result in better allocative efficiency over time as they impose an opportunity cost on less effective farmers who stand to earn more by selling or leasing their quotas to more effective farmers. To better realise these allocative efficiency advantages, input and output quotas should be detached from farmers' rights to the lagoon water and lagoon bed. In the sections that follow, all references to quotas imply tradable quotas.

Changing the property rights regime refers to either privatisation or 'unitisation'<sup>\*</sup> of an open access common pool resource. Privatising the lagoon water (as opposed to the lagoon bed) is not feasible owing to natural movement of water through the Lagoon. In addition, privatising the lagoon water to individual shrimp farmers will not eliminate its over-exploitation if farmers are still able to externalise the cost of pollution by discharging contaminated water into public waterways. Unitisation is discussed in Section 4.4 as a complementary setting for market-based instruments.

##### *4.2. Normative assessment criteria*

Criteria used to make normative assessments of environmental policy instruments typically include their environmental effectiveness, static efficiency, cost-efficiency, flexibility, and political and administrative feasibility (Majone, 1976; Bohm & Russell, 1985, U.S. Department of Energy, 1989, U.S. Congress, 1995; Hole, 1996; Revesz & Stavins, 2007). The relative importance of these criteria depends on prevailing circumstances and priorities. Given the Lagoon's critical livelihoods role, first-order priority was assigned to environmental effectiveness and administrative feasibility. Environmental effectiveness refers to the level of 'action forcing' that an instrument imposes on polluters. Administrative feasibility refers to the amount of money and information required to implement and manage the instrument. Second-order priority was given to static efficiency, cost-efficiency, flexibility and political feasibility. Static efficiency refers to the optimal production level of polluters. Cost-efficiency refers to the extent to which the instrument achieves the intended environmental goal at least cost.

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<sup>\*</sup> Unitisation implies a shift from open access to common property where rates of exploitation are governed by rules established and enforced by, or with, user groups

Flexibility refers to the ability of farmers to respond to the policy instrument and to changes in the business environment, and the ability of administrators to adapt the instrument to changes in ecological and socioeconomic environments. Political acceptability should be considered from both government and community perspectives.

#### 4.3. Assessment of policy options

The analysis summarised in Table 1 assumes that the property rights regime is unchanged and that the policy instruments are imposed by regulators on farmers who have private access to the lagoon bed and open access to lagoon water. The rankings assigned to instruments on each of the assessment criteria are subjective, reflecting the perceptions of key informants in local and provincial government authorities, and insights drawn from the literature. Pollution quotas and taxes were ranked above the other instruments in terms of environmental effectiveness, but were viewed as too costly to administer owing largely to measurement problems. Quota restrictions on shrimp outputs and seed inputs were ranked above output and input taxes owing to their superior cost efficiency, political acceptability and flexibility. Output quotas, unlike input quotas, allow farmers to respond freely to relative changes in input prices. However, seed quotas were considered superior on the first-order administrative criterion because shrimp seed is supplied by a small number of hatcheries. Individually transferable quotas (ITQs) for shrimp seed were therefore selected as the preferred instrument.

Despite their administrative advantage, seed ITQs still pose considerable challenges to implementation. First, the Lagoon would have to be partitioned into zones within which quotas would be transferable. Each zone should be relatively homogeneous with respect to ecology, farmers and their farming practices. Second, technical assessments would be required to determine the aggregate quota for † Unitisation implies a shift from open access to common property where rates of exploitation are governed by rules established and enforced by, or with, user groups. each zone. If substitution between species is to be permitted, then appropriate quota substitution ratios must also be determined. Third, decisions must be taken on the initial allocation of quotas. If quotas are to be grandfathered in proportion to existing levels of production, then recent production information must be gathered for each farmer. Fourth, administrative structures and processes are required to support well-functioning markets for quotas and to prevent farmers from purchasing seed in excess of their quotas.

Table 1. Synthesis of Policy Instrument Assessments

Assessment criteria	Output quotas	Seed quotas	Pollution quotas	Output taxes	Seed taxes	Pollution taxes
<b>Environmental effectiveness</b>	<b>high</b>	<b>high</b>	<b>very high</b>	<b>high</b>	<b>high</b>	<b>very high</b>
<b>Administrative feasibility:</b>	<b>low</b>	<b>high</b>	<b>very low</b>	<b>low</b>	<b>low</b>	<b>very low</b>
- Information cost	high	low	very high	high	high	very high
- Governance cost	high	high	very high	high	high	very high
<b>Cost efficiency</b>	<b>moderate</b>	<b>moderate</b>		<b>high</b>	<b>high</b>	
<b>Static efficiency</b>	<b>low</b>	<b>low</b>		<b>low</b>	<b>low</b>	
<b>Flexibility:</b>	<b>very high</b>	<b>high</b>		<b>low</b>	<b>low</b>	
- Ability of farmers to respond to the	high	high		low	low	
- Ability of farmers to respond to the	high	low		high	low	
- Adaptability of the instrument	high	high		low	low	
<b>Political acceptability:</b>	<b>High</b>	<b>high</b>		<b>low</b>	<b>low</b>	
- Political risk	low	low		high	high	

#### 4.4. Co-management as a complementary policy option

Fishery Associations (FAs) currently operating at the village or sub-village level could be instrumental in reducing the costs of administering seed ITQs. FA's are user groups whose members share similar resource

exploitation practices in a well-defined area of the Lagoon (Tuyen et al., 2010). These user groups would have an incentive to prevent members from overstating their production levels (if seed ITQs are grandfathered) as this would dilute the shares of other members. Second, the cost of monitoring farmer compliance is expected to decline because members of FAs have an incentive to police the actions of other members, and rule-breakers would find it difficult to conceal their opportunistic behaviour from neighbours. Third, FA's would also have a cost advantage over government agencies in collecting and disseminating information needed to support decentralised quota markets. On the other hand, government agencies would have cost advantages in assembling technical information about sustainable production levels in different parts of the Lagoon, establishing quota zones and their aggregate seed quota, and in resolving conflicts between user groups.

## 5. Conclusion

Privatisation of the TGCH Lagoon bed encouraged shrimp farmers to adopt intensive production methods. In the absence of well-defined property rights to lagoon water, farmers over-intensified as they were able to externalise the costs of their water pollution. In addition, the process of privatisation was not well regulated and natural waterways were blocked by earthen walls and fine-mesh nets. This aggravated the pollution problem and shrimps became increasingly prone to disease as the water quality deteriorated.

Well-established relational contracts between shrimp farmers and wholesalers collapsed because the yield losses were widespread and farmers were unable to fulfil their supply contracts. Switching to more disease-resistant aquaculture species comes at the expense of lower profits and may provide only temporary relief from the water pollution problem. Considering the large number of poor households that depend on the Lagoon for a living, it is essential that levels of water pollution be reduced and managed.

The analysis (briefly) reported in this paper suggests that water pollution generated by intensive aquaculture in TGCH Lagoon would best be addressed by allocating seed ITQs to farmers as members of local Fishery Associations, and devolving responsibility for quota compliance and markets to these user groups in order to benefit from their incentive and information advantages. Government would retain an important role within a co-management regime - establishing quota zones and their quota limits, and resolving conflicts between Fishery Associations. While the analysis on which these recommendations are based is not objective in a quantitative sense, the study emphasises the systems view that food chains are shaped by social, institutional and natural settings. To analyse their performance, it is necessary to integrate knowledge of supply chain management, institutional and resource economics, property rights, technology and ecology, and to have a good understanding of the socio-economic and political environment within which the chain operates. This study goes some way towards achieving an integrated approach but falls short of testing its recommendations against the views of communities and farmers who rely on the Tam Giang Cau Hai Lagoon for their livelihoods.

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