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# What drives the adoption of integrated shrimp mangrove aquaculture in Vietnam?

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ABSTRACT

The development of shrimp farming in Vietnam has eroded the social-ecological resilience of the coastal ecosystem. Recent literature supports the idea that integrated mangrove-shrimp production systems can contribute to rebuilding this resilience in the Mekong Delta. Two experts panels, international and Vietnamese, were consulted to validate and weight drivers identified from literature that enable or constraint farmers to shift from extensive production system to integrated mangrove-shrimp system or to continue such integrated system. Though a combination of drivers is needed to enhance changes, two sets of drivers were given the highest weight. Experts considered the ecosystem function of the mangrove an enabling driver pushing farmers to plant mangrove in order to improve the pond's water quality and limit disease outbreaks. They perceived the drivers related to the current regulatory framework as constraining because these limit the financial return associated with integrated mangrove-shrimp systems. The analysis indicates that the adoption of these integrated systems requires more equitable distribution of benefits from shrimp and timber production between farmers and other stakeholder in these value chains. We recommend to develop a regulatory framework that can optimize the financial benefits of the integrated mangrove-shrimp production systems for farmers.



## 1. Introduction

Shrimp farming in Southeast Asia has been a major driver of land use change in coastal regions. The impact of shrimp farming coastal landscapes and ecosystems has been considerable over the previous four decades; between 1970 and 2000 the areal grew at an average rate of 17% per annum (Gowing et al., 2006; Primavera, 2006; Lebel, 2002; Nguyen, 2014). Mangrove forests have been particularly impacted, leading to a degradation of ecosystem services such as coastal protection, erosion control, habitat function, nutrient and waste cycling (Daily, 1997; Norberg, 1999; Sathirathai, 2001; Dahdouh-Gueba et al., 2005; Alongi, 2008; Hussain and Badola, 2010; Manson et al., 2005a & b; Saravanakumar et al., 2008; Turner, 1977; Pauly and Ingles, 1986; Lee, 2004). The productivity and long term resilience of shrimp aquaculture is also dependent on many of these same ecosystem services (e.g. Primavera, 2006; Barbier et al., 2008; Bosma et al., 2014).

Bush et al. (2010; p.15) defined the resilience of a shrimp farm as "the capacity to maintain [its] integrity when responding to external changes and feedbacks within their wider coastal social-ecological system". The resilience of a farm is therefore dependent on both the capacity of a producer to make decisions and adapt to changes and shocks, as well as on the capacity of the ecological system in which the farm is embedded to absorb changes and shocks while maintaining its main functions. Decisions affecting the resilience of shrimp production are also not independent, as they are embedded within wider processes of social, political, economic and environmental change (Bush and Marschke, 2014). These processes are also directional because they influence decisions to shift from one practice to another. On this basis they can be defined as 'drivers' of change, and by characterizing these drivers of change it might be possible to understand how changes at the farm level ultimately influence the coastal landscapes.

The drivers that shape coastal landscape and specifically mangrove ecosystems, are classified as human induced (such as food production systems, urbanization and industrialization, see Nguyen, 2014), and nature-induced (including changes in the

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hydrological system causing coastal erosion or accretion and sea level rise and cascading effects and feedbacks from ecosystem change, see Friess et al., 2012; Balke et al., 2011; Liu et al., 2007). These human and natural drivers of mangrove loss are widely documented, as are the technical aspects of mangrove conservation and reforestation. However, less attention is given to the governance of mangrove reforestation and rehabilitation (Lewis, 2005; Thinh et al., 2009). Just as replanting and/rehabilitating mangroves in and around shrimp ponds can take many forms, steering producers to change their production systems can be done in a variety of ways. One example of conservation and reforestation measures are the different types of integrated mangrove-shrimp production systems providing also livelihoods to shrimp farmers. In these systems shrimp are stocked in ponds with mangroves planted either within the pond or on bunds and/or platforms in and around ponds. These systems are thought to be more sustainable as they are ecologically embedded within the wider coastal ecosystem (Primavera, 2000). Yet despite their potential integrated mangrove-shrimp production systems are not widely practiced.

In this paper we focus on the bottlenecks and potential of steering farmers towards integrated mangrove-shrimp aquaculture systems to contribute in re-building the resilience of coastal zones, and the how farmers can be steered towards (continuous) investment in them. We contribute to on-going debates over coastal change and resilience (Bush and Marschke, 2014) by identifying and weighing the importance of the human and natural drivers in the decisions that farmers make about both shrimp culture practices, shrimp production systems and mangrove cultivation. Using the Mekong Delta in Vietnam as a case study, we investigate the relative importance of these drivers for farmer's decisions to either continue with or adopt integrated mangrove-shrimp farming systems. Our analysis is based on the results of a series of consultations, in which international and Vietnamese experts weighed the relative importance of a series of drivers identified through a review of recent research on farm level decisions that may or may not expand integrated mangrove-shrimp farming in the Mekong Delta.

The paper is divided into three main parts. We first describe the methodology adopted in this research before presenting our results. We then discuss on how different drivers of change influence the resilience of shrimp aquaculture systems, and which new policies can support a more resilient aquaculture development within the coastal zone of the Mekong Delta.

## 2. Material and method

This study uses multi-criteria decision analysis using qualitative weighting of drivers of change (Prato and Herath, 2007). This method was adopted because of the limited quantitative data and information available on many of the drivers identified. The analysis involved three steps. First, a review of recent academic research was completed to characterise extensive shrimp production. Second, a further literature review identified 'drivers' for the adoption or continuation of integrated mangrove-shrimp systems. Third, a relative weight was assigned to the drivers of change by consultations of Vietnamese and international experts.

### *2.1. Characterizing the extensive shrimp production systems*

The analysis of the diversity of shrimp farms in the Mekong Delta is based on i) their interaction with the environment; ii) the regulatory framework supporting the development of shrimp farms and the trade of shrimp through global value chains; and iii) the implementation of disease management practices at the farm level.

The Mekong Delta is characterised by a complex range of shrimp aquaculture systems (Table 1). At one end of the spectrum (Bush et al., 2010), intensive shrimp farming systems are designed to maximize production, with high stocking densities (number of post larvae stocked per square meter), chemical inputs, mechanical aeration, and a single harvest per crop cycle. Farmers manage the production risk by controlling and closing the production system from the surrounding environment, in an attempt to manage the water quality in the ponds and to avoid disease related infections (Joffre and Bosma, 2009). Intensive systems in the Mekong Delta represented about 51,000ha, less than 10% of the total shrimp production area (553,998 ha) in 2009 (Provincial Department of Fisheries in the Mekong Delta, 2009).

The other end of the spectrum is characterised by extensive systems with frequent water exchange, and the natural recruitment of fish, shrimp and crabs through the tidal intake of water, mixed with the frequent stocking of hatchery reared black tiger shrimp (*Penaeus monodon*) at low densities of 1–3 post larvae per square meter (Ha, 2012a). These extensive systems use limited inputs and the risks associated with production are spread over the year through multiple harvests of small to larger sized shrimp. In between these two extremes a range of stocked production systems with intermediate intensity levels of stocking density, water exchange, feeding and water treatment are found. In the Mekong Delta these intermediate systems are labelled as 'improved extensive' and 'semi-intensive' systems; the latter being considered closer to intensive systems because of the higher stocking density and the use of commercial feed.

Extensive production systems in the Mekong Delta are typically farmed by smallholders who raise high value black tiger shrimp. These systems make up 90% (~502,470 ha) of the total shrimp (production area and 60% of the total volume produced in the region (~322,000 tons) (Provincial Department of Fisheries in the Mekong Delta, 2009). Extensive farms are run by households composed of 5–7 persons, from which males are generally in charge of technical decisions (Ha et al., 2013). These households generally have low access to capital, and limited access to infrastructure and electricity. About 75% of the extensive shrimp farmers are indebted, after acquiring formal and informal loans from relatives and/or suppliers. Access to knowledge on production is mostly limited to neighbours, relatives and input suppliers. Extension services have relatively low influence. Shrimp farming is the main income source, but the collective livelihoods of these households remain diverse. The poorest households in these areas remain dependent on inshore fisheries and collection of natural resources from the mangrove ecosystems (Joffre and Schmitt, 2010).

Extensive farms are rarely upgraded to semi-intensive or intensive production because of poor access to finances by small holder producers and volatile price fluctuations. In addition, poor biosecurity and frequent water exchange make these farms highly vulnerable to disease transmission (Hoa et al., 2011). Since the first outbreak in 1994 (de Graaf and Xuan, 1998), White Spot Syndrome Virus (WSSV) has been highly prevalent in the Mekong Delta. In recent years other diseases, such as Acute Hepatopancreatic Necrosis Syndrome, have also become endemic (Lightner et al., 2012; Akazawa and Eguchi, 2013). However, despite their apparent vulnerability to diseases and external shocks, these extensive systems also demonstrate a high degree of resilience to disease. As demonstrated by Dieu et al. (2010), disease causing viruses are less virulent in open extensive systems than they are in intensive systems which invest in higher levels of biosecurity (Hoa et al., 2011).

Extensive systems that integrate the cultivation of mangrove trees have much lower production levels per area than other extensive systems, but also demonstrate a much lower overall risk of crop loss (Ha, 2012a). In 2009, integrated mangrove-shrimp