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Original Articles

Assessing and comparing relative farm-level sustainability of smallholder shrimp farms in two Sri Lankan provinces using indices developed from two methodological frameworks☆,☆☆

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ABSTRACT

As shrimp farming can be an important means of income generation, particularly among Sri Lanka's rural communities, it is important that this industry grows in a sustainable manner, starting at the farm level. The objectives of this study were to; 1) create baseline farm-level sustainability indices for smallholder shrimp farms in Sri Lanka using both content-based and system-based frameworks adapted from agriculture; 2) determine whether arranging indicators within both content- and system-based sustainability frameworks would provide additional insight into relative farm sustainability (rather than using just one framework); and 3) seek differences between the North Western Province (NWP) and the Eastern Province (EP) in sustainability index, sub-index, or indicator scores that might be used to create province-specific policies and education programs designed to potentially improve sustainable practices at the farm level. Since little has been published on the development of practical indicators and evaluation of farm-level sustainability in aquaculture, this study adapted two types of frameworks used for measuring sustainability in agriculture: content- and system-based. Using both frameworks, along with expert opinion, indicators of farm level sustainability were developed into a questionnaire and measured on 225 farms in two provinces of Sri Lanka. Indicators primarily included modifiable practices that farmers could influence to improve the chances of their farms' survival. The farm indicators were normalized using "min-max" normalization, where scores of zero and one were assigned for the least and most sustainable options, respectively. Farm indicators in each province were then aggregated into sub-indices as well an overall aggregated sustainability index score. Similar themes were gleaned from both the content-based and system-based sustainability frameworks, and there was no significant difference between mean overall sustainability scores for the two different frameworks. Farms in the NWP scored significantly higher on the overall sustainability indices of both models despite the NWP's history of severe disease outbreaks while the EP farms had no disease. Possible reasons for this difference were explored with an in-depth analysis of sub-indices as well as individual indicators. An overall aggregated sustainability index score was a useful baseline measure for monitoring changes in sustainability over time; however, its use was limited when attempting to identify gaps in sustainable management practices and provide practical information for farmers and stakeholders to improve farm-level sustainability. It was important to evaluate individual indicators in addition to sub-indices and overall index scores when making recommendations or identifying gaps in sustainable practices at the farm level.

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1. Introduction

Shrimp (*Penaeus monodon*) farming in the North Western Province (NWP) of Sri Lanka has long been an important means of income generation, with over 50% of total export earnings from the fisheries sector being attributed to shrimp farming (FAO Fisheries and Aquaculture Department, 2004). Income from shrimp farming has been considered a way to improve the livelihoods of rural communities where more than 40% of the rural poor are employed as smallholder subsistence farmers and fishers (The International Fund for Agricultural Development, 2007). Near-collapses of the industry in the NWP, however, from white spot disease (WSD) outbreaks in the 1990s and 2003 (Siriwardena, 1999; Weerakoon, 2007), have highlighted the need for better management practices on farms to enable sustained survival of the shrimp farming industry in this province. Additionally, shrimp farming in the Eastern Province (EP) has recently been revived since the end of the civil war, thus providing an opportunity to implement more better management practices.

While the need to promote sustainable growth of the shrimp farming industry has been noted in the literature (e.g., Béné, 2005; Corea et al., 1995; Flegel and Alday-Sanz, 1998; Folke and Kautsky, 1992; Godfray et al., 2010), little has been done to determine and measure practical indicators that may affect farm-level sustainability, where farmers' individual perceptions and behaviors affect their management practices. This is partially due to the existence of numerous definitions of sustainability and the recognition that the parameters governing sustainability differ between societies (e.g., Bosshard, 2000; Gómez-Limón and Sanchez-Fernandez, 2010; Hansen, 1996; Pannell and Glenn, 2000; Rigby et al., 2001). Regardless of the definition used, there is a general consensus that to be considered sustainable, a farm must include all three dimensions, or "pillars", of sustainability: social, ecological, and economic (Gómez-Limón and Sanchez-Fernandez, 2010; Pope et al., 2004; Pretty, 2008).

For the purposes of this study, farm-level sustainability was equated with farm survival, since smallholder shrimp farmers in Sri Lanka have historically experienced large amounts of income uncertainty primarily due to production losses from disease outbreaks. This has resulted in farmers frequently entering and leaving the industry over short periods of time (Wijegoonawardena and Siriwardena, 1996). As a result, in this area, short term sustainability, or the ability for the smallholder farm to survive, is essential before longer term sustainability can be addressed. While individual farmers cannot directly influence external factors such as government policies and market demand that are likely to affect sustainability in the long term, they can change and adapt management practices to help their farms survive.

As published studies evaluating multi-dimensional frameworks for measuring farm-level sustainability in aquaculture were not available at the outset of this study, frameworks had to be adapted from those used in agriculture. Frameworks for selecting indicators of sustainability at the farm level can be divided into two main types: a) content-based; and b) system-based (von Wiren-Lehr, 2001; Van Cauwenbergh et al., 2007). Indicators developed using content-based frameworks characterize individual parts of the system of concern (Center for International Forestry Research, 1999; Van Cauwenbergh et al., 2007), and are based on *principles*, *criteria*, and *indicators* (Van Cauwenbergh et al., 2007). The indicators are typically arranged according to the three pillars of sustainability. System-based frameworks use general attributes of a system to evaluate the sustainability of that system regardless of the hierarchical level or disciplinary bias (Conway, 1994; López-ridaura et al., 2005). The attributes include *productivity*, *stability*, *reliability, resilience,* and *adaptability* (López-ridaura et al., 2005; López-Ridaura et al., 2002; Speelman et al., 2007). These attributes are not explicitly divided according to pillars. Both types of frameworks are likely to identify similar indicators for a given system if information is collected solely using a questionnaire and a cross-sectional study design; however, each would aggregate the indicators differently according to each framework's specific attributes or pillars. Using multiple frameworks could enable potentially different interpretations of sustainability. As a result, this study compared both content- and system-based frameworks to determine if any differences in sustainability existed due to the framework used (Van Cauwenbergh et al., 2007; von Wirén-Lehr, 2001).

The objectives of this study were to: 1) create baseline farm-level sustainability indices for smallholder shrimp farms in Sri Lanka using both content-based and system-based frameworks adapted from agriculture; 2) determine whether arranging indicators within both content- and system-based sustainability frameworks would provide additional insight into relative farm sustainability (rather than using just one framework); and 3) seek differences between the North Western Province (NWP) and the Eastern Province (EP) in sustainability index, sub-index, or indicator scores that might be used to create province-specific policies and education programs designed to potentially improve sustainable practices at the farm level.

2. Materials and methods

2.1. Study area

This study was conducted in the North Western and Eastern provinces of Sri Lanka (Fig. 1). The NWP is in the administrative district of

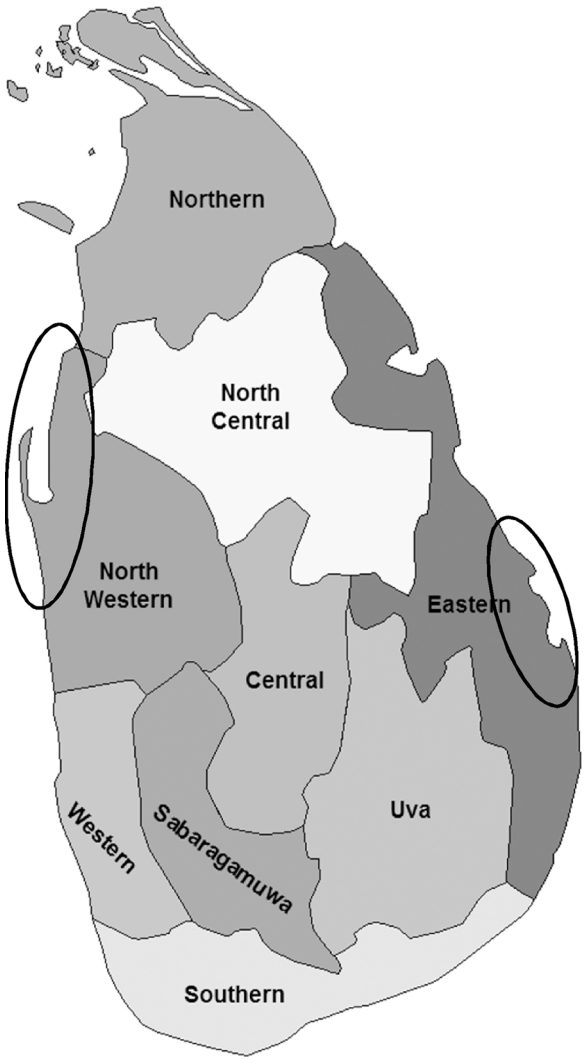

Fig. 1. Map of Sri Lanka adapted from www.worldofmaps.net (public domain). Study sites in the North Western Province and Eastern Province are circled.