International Journal of the Commons
Vol. 9, no 1 March 2015, pp. 347–368
Publisher: Uopen Journals
URL:http://www.thecommonsjournal.org
URN:NBN:NL:UI:10-1-116933

ISSN: 1875-0281

Drama of the commons in small-scale shrimp aquaculture in northwestern Sri Lanka

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Abstract: Aquaculture, and shrimp aquaculture in particular, can have major social and environmental impacts. However, aquaculture remains an understudied area in commons research. Can aspects of commons theory be applied to solve problems of aquaculture? We examined three coastal community-based shrimp aquaculture operations in northwestern Sri Lanka using a case study approach. These shrimp farms were individually owned by small producers and managed under local-level rules designed by cooperatives (*samithi*). The common-pool resource of major interest was water for aquaculture ponds, obtained from an interconnected water body. We evaluated the shrimp farming social-ecological system by using Ostrom's design principles for collective action. Key elements of the system were: clearly defined boundaries; collaboratively designed crop calendar, bottom-up approach involving community associations, multi-level governance, and farmers-and-government collaborative structures. Together, these elements resolved the excludability and subtractability problems of commons by establishing boundary and membership rules and collective choice rules.

Keywords: Commons, community-based management, farmer associations, institutions, shrimp aquaculture, small-scale aquaculture, Sri Lanka

Acknowledgements: We thank the shrimp farmers of northwestern Sri Lanka, and gratefully acknowledge Rohan Paaris from the Sri Lanka Aquaculture Development Association for his invaluable support and guidance. We thank Upali Amarasinghe (University of Kelaniya, Sri Lanka) and Iroshani Tennakoon

(Manitoba Health) for help and for sharing valuable thoughts and experiences. The study was supported by the Canada Research Chairs Program (http://www.chairs-chaires.gc.ca).

1. Introduction

Considering the importance of aquaculture in rural livelihoods, especially in Asia (Campbell and Pauly 2013) it is surprising that it has received so little attention from commons scholars. Aquaculture is estimated to contribute nearly 50% by volume to the world fish supply, and is very important for the food security of many countries such as China. Aquaculture provided only about 4% of the world fish supply as late as 1970 but grew on the average by 10.2% per year, higher than any other animal protein food source (Pullin 2013). Within the aquaculture sector, world shrimp production also showed a tremendous growth, from 1600 tons in 1950 to close to 4.5 million tons in 2006 (FAO 2009). The monetary value of the industry in 2006 was about US$18 billion (FAO 2009) and provided attractive profit margins. However, aquaculture in general, and shrimp aquaculture in particular, also has social and environmental costs.

Pullin (2013, 96) points out that aquaculture has a "bad image and gets bad press where it is blamed, whether entirely correctly or not, for adverse impacts on nature and natural resources." Many of these impacts are real. For example, clearing coastal wetlands for aquaculture often results in biodiversity loss in coastal environments (Valiela et al. 2001; Alongi 2002). Naylor et al. (2000) point out that aquaculture production is often made possible by funnelling natural biological primary production from a large region into a small area for intensive production. Marine aquaculture, for example, salmon pen culture, "looks" small but tends to have a large ecological footprint. Coastal aquaculture in tropical regions, and shrimp aquaculture in particular, has adverse impacts on valuable natural systems such as mangroves (Primavera 2006).

Aquaculture also has social or socio-economic impacts (Primavera 1997). The creation of social injustice in shrimp farming areas due to large-scale commercial, corporate based aquaculture has been pervasive (EJF 2003). Attractive profit margins, particularly related to high-value large-sized shrimp (prawn) aquaculture, drive the displacement of small-scale capture fisheries by aquaculture. There is no "free space" in the world; the space coveted by aquaculture tends to be occupied by other uses of the coastal zone. One example is India's Chilika Lagoon where export-oriented aquaculture for tiger prawn (*Penaeus monodon*) has marginalized some 400,000 people in 150 villages of caste-based small-scale fishers (Nayak and Berkes 2010). The displacement created poverty and destitution and a food insecurity crisis, with implications for India's performance regarding Millennium Development Goals (Nayak and Berkes 2014). Obviously, there are success stories of aquaculture as well. In some cases, small-scale fishers have transitioned from capture fisheries to higher-value aquaculture production (De Silva and Davy 2010) or small farmers have been brought together into associations to foster collective action (Umesh et al. 2010). However, even in such cases, the development of aquaculture can create social inequities in the community; some groups are able to adopt aquaculture technology more readily than others because of differences in resource access rights or social/cultural reasons (Huong and Berkes 2011).

Sustainability looms as a large problem in aquaculture. Complexities of shrimp aquaculture create difficulties in management (Bush et al. 2010) because of uncertainty brought by shrimp disease, ineffective decision making as a result of scale issues, conflicts of multi stakeholder interests and others. Almost all shrimp production systems experience similar risks in regard to production and marketing (Hall 2004; Bush et al. 2010) and shrimp diseases (Vlak et al. 2005).

Shrimp disease is a key variable in aquaculture sustainability. Huitric et al. (2002) were able to track shrimp aquaculture development all the way around the Gulf of Thailand, as commercial shrimp farms collapsed one after another due to disease after only a few years of operation, and new ones were established in new areas along the coast.

Solutions to the problems of aquaculture have predominantly emphasized technical approaches. Costa-Pierce (2002) summarized the issue as one of “paradigm change” towards an aquaculture revolution that is technically sophisticated, knowledge-based, and ecologically and socially responsible. Pullin (2013) provided examples of the use of vegetable proteins (thus reducing the need for fishmeal), and finding cheaper sources of lipids in farmed fish feeds (thus conserving nutritious fish oils for direct human consumption). Bush et al. (2010) analysed social-ecological systems in the context of shrimp aquaculture in coastal areas of Southeast Asia, and identified two scenarios for resilient shrimp aquaculture, namely landscape integrated systems and closed systems.

Little effort has gone into the exploration of commons and collective action approaches for solving the problems of aquaculture. Apparently, scholars consider aquaculture not to be part of the main commons area, as there are only a few references to it in the commons literature (Bush et al. 2010; Galappaththi and Berkes 2014). Exceptions include Huong and Berkes (2011), Armitage et al. (2011) and Marschke et al. (2012). Can aspects of commons theory be applied to aquaculture? Are there key common-pool resources in the context of shrimp aquaculture, and if so, how can they be managed?

In general, commons are resources that are owned and/or shared by a group of people, and that produce collective action problems. Commons (or common-pool resources) share two characteristics: exclusion or the control of access of potential users is difficult, and each user is capable of subtracting from the welfare of all other users. Thus, common-pool resources (commons) have been defined as those “in which (i) exclusion of beneficiaries through physical and institutional means is especially costly, and (ii) exploitation by one user reduces resource availability for others” (Ostrom et al. 1999, 278). The first characteristic, excludability, is about controlling access to the resource. For example, a set of established users of lagoon waters may want to exclude other potential users because there is only so much water that can be used by all. The second characteristic, subtractability, means each user is capable of affecting the ability of all other users to exploit the same resource (Feeny et al. 1990). For example, the discharge of waste water, with pollutants and pathogens in it, from one aquaculture operation can affect all others using a common water source.

These are collective action issues – how to design institutions to achieve long-term community benefits, rather than short-term individual benefits – to which there are no set answers (Ostrom 2005). The rules to control the access to resources and to address the subtractability problem may be made by the government, or markets, or communities themselves, or by any combination thereof (Berkes et al. 2001). Elinor Ostrom studied long surviving commons institutions and came up with a set of broad institutional regularities among systems that survived over a long period of time and that were absent in failed systems. Ostrom (1990) named these regulations "design principles". Originally, she formulated eight design principles. Cox et al. (2010) analyzed 91 studies that explicitly or implicitly evaluated these design principles, and concluded that the principles were robust. But they also came up with some revisions, splitting three of the principles.

Sri Lanka provides a suitable setting for addressing some of these commons issues. Sri Lankan coastal shrimp aquaculture is restricted to the shrimp farming communities in the northwest, mostly growing tiger shrimp (*Penaeus monodon*) for international markets. The structure of the Sri Lankan shrimp aquaculture has evolved from large-scale company-based management to small-scale farm-level and community-based management over the last three decades. The driver of this change was the collapse of large operations due to recurrent shrimp disease, and the appearance of small, family farm sized operations in their place (Galappaththi 2013). As with agriculture in Sri Lanka, shrimp farmers are organized into cooperatives. Sri Lanka has a long history of cooperatives (called *samithi* in the local language) in other kinds of aquatic resource management as well. For example, Negombo stake-net fishery in northwestern Sri Lanka has been managed by cooperatives for more than 250 years (Atapattu 1987; Amarasinghe et al. 1997; Gunawardena and Steele 2008). This fishery is in the control of rural fisheries societies based in villages around the Negombo Lagoon. These societies function as commons institutions and play a major role in community-based resource management. They decide on membership eligibility and obligations of members. Many Sri Lankan fish farms are also managed as cooperatives (Amarasinghe 2010).

In the study area, large-scale shrimp aquaculture was carried out until the mid-1990s (Galappaththi and Berkes 2014). The initial success of large-scale shrimp farming had attracted investors, including political leaders. But the boom ended in a "bust", as elsewhere (Huitric et al. 2002). The small-scale shrimp farmers in the area gained their technical know-how by working for these big aquaculture companies and started their own operations, taking advantage of the collapse. Many of the farmers also had capture fishery experience. Even though shrimp aquaculture was transformed into a community-based system, some political influences still persist. For instance, as most of the land in the northwestern region is government land, certain politicians have been using their power to occupy wetlands. Another power-related issue has been the lack of price-bargaining power of small producers over harvest prices, leading to lower profit margins. Shrimp processing companies dominate price negotiations. This paper is not about the wider shrimp industry related aspects, such as supply chains, influence of the actors on shrimp prices and productivity. Basically, most of the prime-quality tiger shrimp from this area goes to international markets, and the rest to local markets. The farm-gate price to farmers is decided by individual weight and grade (quality) of shrimp, and changes daily according to market prices (more detail in Galappaththi 2010).

This paper addresses some questions related to common–pool resources in small-scale shrimp aquaculture in Sri Lanka. First, what are the key common-pool resources involved, and what advantages might be there to manage such resources as commons? Second, can the success of commons arrangements be substantiated, and if so, how can this be best understood? Following a section on study area and methods, we examine the resources involved, the common water supply used for aquaculture, discuss the operation of shrimp farms and how they manage the shared water supply. The analysis is structured around the two characteristics of commons (excludability and subtractability), and we evaluate these shrimp aquaculture systems against the revised Ostrom design principles (Cox et al. 2010). Our case is a "drama" in the same sense as Ostrom et al. (2002), as it is neither a "tragedy" (Hardin 1968) nor a "comedy" (Rose 1986; McCay 1996) but shows the real-life struggles in Sri Lankan shrimp aquaculture in solving commons problems.

2. Study area and methods

Most of the lands in the northwestern area are wetlands, mangrove areas, and lagoons. Coconut cultivation has traditionally been the main economic activity in the region. However, the livelihoods of villagers vary by area (see below). The majority of the lands that were later converted into shrimp farms were state property. Large companies leased government lands to build shrimp farms. To date, there are unresolved disputes over land ownership. In 2012, 243 shrimp farms were awaiting to be licensed, a process slowed down due to land ownership issues. There were many abandoned shrimp ponds in the northwestern region which cannot really be used for any other purpose.

A qualitative research study was conducted in the coastal communities of *Ambakandawila*, *Koththanthive*, and *Karamba* located in northwestern Sri Lanka (hereafter referred to as communities A, B, and C respectively). There were two main criteria in selecting these three communities. The first criterion was to capture the entire process of shrimp farming operation within the available timeframe of the study. During the field work period, these communities were in different stages of the shrimp farming process. For example, during the month of May, community A was in the middle of farming; community B was in the harvesting stage, and community C was in the pond preparation stage. The management activities and focus of the community-level shrimp farmers' associations varied according to the production stages of farmers in the community. For example, the main concern of community C was to finish postlarvae (shrimp "seed") stocking prior to the management deadline. Community A, which was in the middle of the shrimp growing stage, focused on protecting farms from shrimp diseases.

The second selection criterion was to capture a diversity of cultural and ethnic backgrounds. Community A was Sinhalese (100%); community B was Tamil (100%); and community C was comprised of a mix of residents of Sinhalese, Tamil, and Muslim backgrounds. The selected communities were located in three different geographical parts of the northwestern area, as shown in Figure 1. Community A is an isolated rural community located close to *Chilaw* Lagoon, with about 150 households. Income generating activities included shrimp farming, shrimp hatcheries, brood stock supply, and shrimp feed sales. Also important were the coastal fishery, government jobs, and money lending. Community A was a fishing community even before big aquaculture.

Community B, another isolated rural community, is located around the mid-northwestern coast, close to *Mundal* lagoon. It has about 200 households involved in

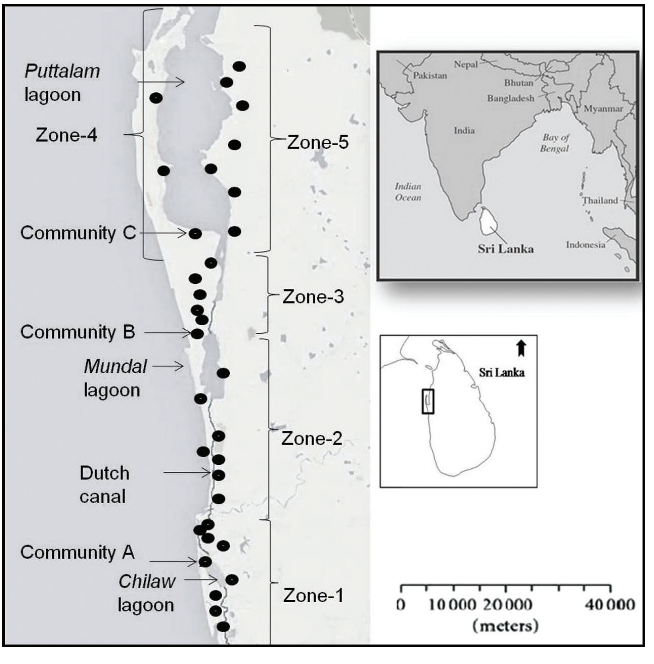

Figure 1: Study area: Three coastal communities (A, B, and C), and the distribution of communal institutions (community associations/samithis) in northwestern Sri Lanka.

capture fishery, paddy (rice) farming, and coconut plantations. Community C, also an isolated rural community, is located near the *Puttalam* lagoon on the northern coast with about 150 households. Income generating activities included cement and salt manufacturing. Before big aquaculture, the lagoon-based fishery, and vegetable and fruit farming were the main income generating activities. At the time of the study, other than aquaculture, the most common activities were small-scale salt ponds, vegetable and fruit trading; and dried fish processing. All three communities were practicing collective action in capture fisheries, even prior to big aquaculture, through lagoon and coastal fishery associations (Galappaththi and Berkes 2014).

Research strategy adopted in the study was the case study approach as it enables obtaining of a rich understanding on the context of the case being investigated (Yin 2009). Data collection took place April – August, 2012. Primary data were collected through multiple techniques: (a) participant observation in the three communities and other parts of the northwestern area; (b) semi-directive interviews with shrimp farmers and shrimp farming community associations; (c) focus group discussions; and (d) key informant interviews with influential people involved in shrimp farming. Three research assistants recruited from the communities assisted with the interviews and focus group discussions, which were used in primary data collection and in validation. As well, the researcher observed 12 community-level meetings and five national-level meetings. Snowball sampling technique was used to interview a total of 38 shrimp farmers (13 in community A, 11 in B, and 14 in C). There were three focus group discussions and seven key informant interviews.

3. Results

3.1. Common-pool resources in shrimp aquaculture

Our study takes a social-ecological systems approach, with attention to core systems and their interactions (Ostrom 2009). The common-pool resource of primary interest in the context of shrimp aquaculture in the northwestern Sri Lanka is water (and not the shrimp which is owned by individual farmers). The common water body is the main water source for shrimp farming operations. There are about 600 shrimp farms drawing water from this common water source. A reliable and consistent supply of water is crucial for shrimp farming. Our field calculations show that the water requirement for operating a 0.5 hectare pond during a single culture cycle (4 months) is more than 20 million liters. Brackish water (partially saline water) is the medium required for tiger shrimp. Specific water quality parameters are required with respect to, for example, salinity, temperature, pH, dissolved oxygen, and ammonia.

3.2. Interconnected common water body

A single interconnected water body serves the shrimp farming area, connected by the Dutch Canal (Table 1). Three lagoons, *Puttalam* (28,000 ha), *Mundal*

Table 1: Historical background: Use and management of the Dutch Canal.

Prior to big aquaculture	During big aquaculture	Small aquaculture
Dutch Canal was made during the Dutch colonial period (1658–1795) for transportation of goods from western coastal areas to the Colombo port. It runs northbound from *Kelani* river in Colombo and drains off to *Puttalam* lagoon. It creates a common water body in the area by connecting *Mundal* and *Chilaw* lagoons. A system of streams and small waterways was also available in this area. There was not much government or public attention in managing the lagoon water or the Dutch Canal.	With the expansion of shrimp farming, Dutch Canal became the main brackish water source for aquaculture ponds. A canal system was constructed in the area for shrimp farming purposes by inter-connecting the small streams through canal branches. Few farmers also started farms (medium-scale) to produce shrimp for the large corporations. These farms collectively withdrew a large amount of water and discharged effluents at the same time.	A large number of small scale farms collectively created the demand for water. As discussed under the section on the zonal crop calendar system, shrimp farming cooperatives and the government collaboratively developed a calendar to manage the use of the water body using temporal and spatial boundaries. Rules were introduced and implemented by the community level cooperatives to control withdrawal of water and discharge of effluents, and not to mix the two.

(3600 ha), and *Chilaw* (700 ha) constitute the main parts of this water body. Dutch Canal starts from *Kelaniya* River near Colombo, runs north and drains to *Puttalam* Lagoon in the northwest. *Kala Oya, Daduru Oya,* and *Maha Oya* are the three main rivers are connected to this water body. *Kala Oya* directly empties to *Puttalam* Lagoon. *Daduru Oya* and *Maha Oya* cross the Dutch Canal in their journey to the sea. There are other relatively small rivers and streams connected to this water body (namely, *Karabalan Oya*/*Lunu Oya* in *Thuduwawa* area; *Mundal* lake at *Udappu* North area; *Sengal Oya*, *Ratambala Oya*, *Battulu Oya*, and *Madurankuli* stream). There are hundreds of streams, man-made water canals, and canal branches bringing water to the shrimp farming ponds (inlet canals) and draining excess and/or used water (outlet canals). Almost all shrimp farms in northwestern area are directly or indirectly linked to this interconnected common water body for the purposes of farming shrimp.

3.3. Small-scale operations using a smaller water body

Size of the farm is an indicator of the scale of operations. In 2012, 55% of the farms were one to three ha in size; 13% of farms was less than one ha; 16% was of three to five ha; 11% was of five to seven ha; and 5% was with more than seven ha. None of the farms in community B was more than five ha, and none of the farms in community C more than seven ha. Some 37% of the farms had two to five ponds; 29% had five to ten ponds; 18% had ten to fifteen ponds; 11% had one pond; and the remaining 5% had more than 15 ponds. Size of the smallest pond was about 0.2 ha and the largest about 0.8 ha. Certain ponds in some farms were kept idle due to various, and often multiple, reasons. Main reason provided by the farmers (95%) was the shrimp disease risk; they were reluctant to invest in full capacity and preferred to keep some ponds in reserve. Other reasons were lack of labour; relatively low profit margins and increasing costs; limited production quota issued by farmer co-operatives; and pond disinfecting (draining a pond and exposing it to sunlight, presumably reducing disease risk).These numbers indicate that northwestern Sri Lanka's shrimp farms can be characterized as small-scale.

As most shrimp farmers once worked in large-scale shrimp farms before they collapsed, they are knowledgeable about both large and small-scale aquaculture. We asked them to compare and contrast small and large-scale operations in three focus group discussions. More than 63% of shrimp farmers (38 farmers in total) believe that small-scale shrimp farming creates relatively low impacts on the environment, as compared to large-scale operations. Table 2 represents the consensus of 38 farmers in support of this argument. Small farms release relatively smaller amounts of waste water to the common water body from time to time during the culture period. The environment has the capacity to absorb this waste water, in contrast to that of larger farms where waste is released in larger amounts all at once. Further, economic loss due to shrimp diseases is relatively less in small-scale operations. Family-based small farms allow for frequent monitoring for shrimp diseases, which limits the potential for higher economic damage. Even under disease conditions, the net economic damage is relatively low as the shrimp can still be sold at market prices (if disease is detected at an initial stage). Lower input cost and smaller investments in the operation as a whole are also factors contributing to economic viability.

3.4. How to manage the common water body

In Sri Lanka's small-scale shrimp farming industry, the social-ecological system of shrimp, water and people (Ostrom 2009) are managed by a mixed commons regime of private, communal, and government controls. Shrimp farms are privately owned. The main community-based institutions are shrimp farmers' associations

Table 2: Comparison of impacts: small-scale vs. large-scale.

Concerns	Small-scale farms	Large-scale farms
Amount of waste water released to the environment (common water body)	Relatively low	Relatively high
Nature of waste water release	Small amounts of water intermittently	Large amount of water all at once
Environment's ability to absorb the waste water from ponds	Relatively high	Relatively low
Economic loss due to disease conditions	Relatively low	Relatively high

or *samithi* that represent individual shrimp farmers. Community institutions manage community-level farming activities, with government oversight and collaboration. Major activity performed by this joint regime is the implementation of the “zonal crop calendar” system.

The almost uncontrollable nature of shrimp disease and the resulting impacts to shrimp farmers and other stakeholders led to the development of the zonal crop calendar system. Basically, the calendar is a defensive measure, or management approach, to contain shrimp disease. It was initially introduced by the Sri Lankan Aquaculture Development Association (SLADA) in 2004, and the implementation of crop calendar was formalized by the Fisheries Ministry of Sri Lanka. Objective of the crop calendar is to minimize the damage caused by shrimp diseases (mainly White Spot Syndrome -WSS) in order to increase national level of shrimp production. It provides an annual plan for shrimp farming in northwestern area.

The foundation of the crop calendar is the zonal and sub-zonal boundary system based on the connected nature of the water body in the northwestern area. Considering the shrimp disease spreading patterns through the water body, the area is divided into five zones (Figure 1) and 32 sub-zones. A calendar year is comprised of three seasons of production: pre-*yala* (February–April); *yala* (April–September); and *maha* (October–February). Production seasons are assigned to sub-zones/farming communities by considering the disease spreading patterns along the water canal system. Each community gets at least one production season per year, but communities and individual farms within them do not have free-access to the water body for water withdrawal and discharge. Their production cycles have to follow the calendar, thus limiting the possibilities of disease spread. The zonal crop calendar is the most significant component of the existing management system, as it affects all the other activities related to shrimp farming, such as seed production and shrimp production volume.

Development and implementation of the zonal crop calendar is coordinated by a government institution, NAQDA (National Aquaculture Development Association), through a collaborative process. The crop calendar is reviewed annually, and both government representatives and shrimp farmers participate in the process. Following negotiations, a consensus is reached on who can carry out shrimp farming in the following year and who cannot. Lessons learned by implementing the previous year’s crop calendar is incorporated into the planning, thus continuously improving the crop calendar to suit prevailing conditions such as weather, canal water flow patterns, water availability/salinity, and disease prevalence. Community associations meet during and after each crop season to discuss, evaluate and come up with adjustments needed for the ongoing and the upcoming crop. These feedbacks and suggestions are transmitted to the national level crop calendar development meeting through sub-zonal and zonal representatives. Hence, the zonal crop calendar designed for a particular season is the outcome of a continuous leaning process.

From a commons management point of view, the crop calendar is a way of addressing the excludability problem (Ostrom et al. 1999) by controlling the access to the common water body.

A second way of addressing the excludability problem is through the rules made by community-based institutions. Privately owned farms are managed under community-level rules. Shrimp farmers' associations collectively formulate their own rules to limit outside shrimp farmers from entering their farming communities (sub-zones or zones). If an outsider wants to start shrimp farming in a particular community, attendance in association meetings for a minimum period of 6 months is mandatory to be eligible for membership. Another rule is that the existing members cannot rent or lease their properties to other potential shrimp farmers without having the consent of their community association.

The subtractability problem (Ostrom et al. 1999) in shrimp aquaculture is mostly associated with the discharge of waste water. If a farmer releases disease-infected water from a shrimp farming pond into the interconnected common water body, this action affects the ability of other shrimp farmers to produce shrimp. If a particular farm is infected at a late stage of the production cycle, the rational behavior of the farmer is to harvest the pond as soon as possible (before the quality of shrimp deteriorates) in order to make a good return on the investment. If the farmer releases contaminated pond water to the common water body, there is a high possibility for the disease to spread into other farms. Besides, other farmers may or may not be at a stage to survive their culture cycle. Release of disease-infected water can affect the livelihood of the community shrimp farmers as a whole.

Better management practices (BMPs) is a set of rules developed by the government institution to be adapted at the community level. For example, BMPs specify a stocking density depending on the use of aerators (i.e. four to six postlarvae/m^2 for a pond with no aerators; or maximum of 10 postlarvae/m^2 for a pond with aerators). Community associations are expected to adapt and fine-tune these BMPs to suit their own environmental and social conditions, such as salinity levels (which determine the need for aeration as supplied by paddle wheels), availability of mangrove vegetation close to farms, success of previous crops, and type of main water source in the community.

> Adapting better management practices and crop calendar system are the key aspects. This is where our focus is… Maintaining an environmentally friendly shrimp farming operation is what we try to achieve here… – Government officer, NAQDA

> …I think now we have the foundation to think about doing shrimp farming in a sustainable way. It is important to strengthen the community level shrimp farming associations and the collective decision making process. To come to this stage, we all had gone through very hard experiences… It is very difficult

> to change farming attitudes of people. But, community associations help us reach shrimp farmers… – Government officer, NAQDA.

3.5. Why collective action is important to manage the common water body

As discussed in 3.4, the interconnected common water body can act as a shrimp disease spreading medium. In the past, Sri Lanka's large-scale shrimp aquaculture experienced three major shrimp disease outbreaks. The first outbreak was during 1988–1990s by Monodon Baculo Virus (MBV), which stunts growth of shrimp. The second outbreak was in 1996 causing WSS. In 1998, both Yellow Head Virus (YHV) and WSS infestations took place. WSS is the current major threat to shrimp aquaculture in Sri Lanka (Munasinghe et al. 2010). WSS is a viral disease mainly infecting Penaeid shrimp species. WSS can kill shrimp within about 24 h and can spread rapidly using other aquatic animals (crustaceans, birds, etc.) as carriers. Hence, shrimp diseases like WSS are a direct threat to the socio-economic wellbeing of small-scale shrimp farmers, and collective action is required to contain the disease before it spreads throughout the entire water system. Thus, in 2005/2006, shrimp farmers and the government jointly introduced a creative way of managing shrimp diseases by controlling access to the common water body.

The key commons institution in this process was the *samithi*, the shrimp farmers' association. The *samithi* plays a large role in managing all aspects of shrimp aquaculture, and all producers have to be members. All meetings organized by the *samithi* are important, as most of the commons problems are discussed during these meetings. Members debate their concerns and heated discussions are common on most occasions. For instance, on one occasion the membership debated a request for a 10 day extension for postlarvae stocking, as proposed by some members (based on their individual circumstances). In another community meeting, there was a discussion about delaying stocking dates until all the farmers were done with harvesting, as some farmers were behind schedule. Some of the items debated in the *samithi* meetings may be larger issues involving other associations. During a monthly meeting at community C, a farmer raised a concern – outlet water canal of a farm belonging to another community association leaking waste water into the inlet canal of a community C farm. This is in fact exactly the way that disease may spread. This concern was addressed by community C's leadership through a phone call to the other community, and by coming to an agreement that the offending farmer repair the canal immediately.

> Now every shrimp farmer has to go through the community association to do shrimp farming… Unlike early days; now it is controlled. No shrimp farmer can do farming beyond the crop calendar – President, community association A

> …We spent lots of time and effort to come to this level. Still we have a long way to go. This association is one of oldest shrimp farming associations in Sri Lanka – President, community association B

Institutions concerned with shrimp aquaculture have evolved over the decades. During big aquaculture, there were four large multi-national shrimp corporations and a growing number of medium and small-scale farmers. Government involvement in managing shrimp aquaculture was negligible. Community associations run by small and medium shrimp farmers started to pop up, especially in the wake of the 1996 disease outbreak. Dependency of shrimp farmers on these institutions was initially minimal, depending on individual needs. Then existing community cooperatives functioned individually at the community level. There were no government line institutions for managing aquaculture.

During the small aquaculture period from the early 2000s onwards, community-level associations started to gain membership and legal status. They started to function collaboratively with neighbouring communities, leading to the establishment of a multi-level institutional structure consisting of the community level, zonal level and national level, as explained in the next section. An existing agency, NAQDA, was tasked as the key government institution to facilitate regulation of shrimp aquaculture. NAQDA started to work in collaboration with the industry. Presently, the dependency of the shrimp farmers on these institutions is very high. Association membership is a mandatory requirement for shrimp farming. Development and enforcement of rules and regulations is done through the multi-level structure.

3.6. Application of Ostrom's design principles

Spatial (zones) and temporal (crop calendar) aspects of the organization of shrimp farming seem to be key to the successful commons management. As well, the multi-level governance of the system is an important aspect. Thus, we discuss these two aspects before evaluating the shrimp aquaculture system through Ostrom design principles.

Sub-zones are represented by shrimp farmers' associations; some sub-zones are in clusters due to small number of members. The elected officers of the community association include: president, vice president, secretary, treasurer, and assistant treasurer. As of 2012, there were 18 community associations representing 32 sub-zones. Community associations are responsible for formulating community level rules required for managing community level activities. For example, community rules specify that a pond should not be harvested when shrimp are less than a month old or <5 g in average weight; water should not be released or pumped before completing a culture period of at least 2 months (community A); and partial harvesting is prohibited (community A). Conflict resolution and sanctions for rule violation is another important role of the community association. Most of the community associations have government aquaculture extension officers working with them to ensure that the practices comply with the national level regulations. However, the officers do not have power to influence decisions made by associations. The election process and all the decisions including rule-making and amending are carried out collectively.

From the shrimp aquaculture management perspective, community/sub-zonal associations are the lowest (bottom) level self-organization within the hierarchy of governance structures from community to national level. These associations represent an overriding collective group. Leaders of these sub-zonal associations represent the community at zonal level associations. All the zonal and sub-zonal associations are collectively represented in SLADA, the industry association. There is at least one representative from each zone and sub-zone. SLADA and NAQDA collaboratively form the top level of the joint management body. This vertically and horizontally integrated multi-level governance structure (Figure 2) facilitates the feedback process in the development of the annual crop calendar.

Can the success of these commons arrangements be substantiated, and if so, how can they be best understood? The design principles originally formulated by Ostrom (1990) to characterize robust commons institutions, and revised by Cox et al. (2010), may be used to understand evaluate the level of success of small-scale shrimp aquaculture in northwestern Sri Lanka. Table 3 provides an overview of whether the design principles are fulfilled. Column 1 indicates the principle, column two the level of compliance or whether the case satisfies the principle, and column three provides the details of the case as relevant to a given principle.

The levels of compliance with the design principles were determined as follows. First, we divided each principle into components to be evaluated. For

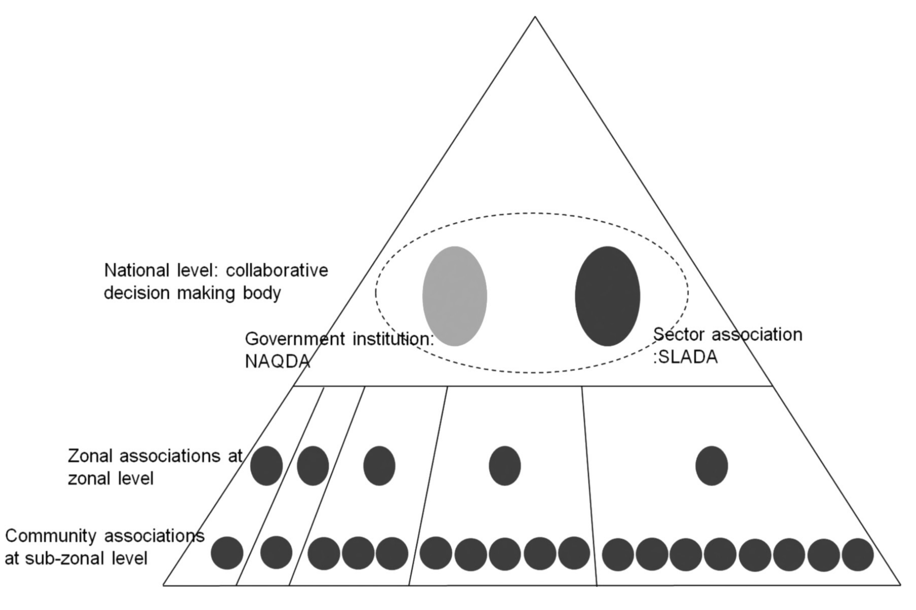

Figure 2: Multi-level governance structure of small-scale shrimp farming.

Table 3: Application of revised design principles for robust commons institutions and collective action (*Ostrom 1990; Cox et al. 2010*).

Principle	Level of compliance with the principle	Description
1A: Clearly defined user boundaries	High	Zonal/sub-zonal boundaries: Zones and sub-zones are defined for resources management purposes. Clearly understood physical (rivers, canals, streams, etc.) as well as virtual boundaries (e.g. divisional secretariats – an administrative boundary) demarcate shrimp farming communities (sub-zones). Shrimp farmers belonging to a community should not take water from the common water body in another community. Non-shrimp farming communities also exist as neighboring communities (if there is no water supply for them to engage in shrimp farming).
1B: Clearly defined resource boundaries	High	Resource boundaries are same as user boundaries.
2A: Congruence between rules and local conditions	High	Crop calendar: Shrimp farmers are allowed to take water from the common water body only during a certain period of the year based on a collectively agreed/developed crop calendar. Better management practices: Rules/guidelines related to better management practices in shrimp farming are formulated by the government institution and are adapted at the community level.
2B: Proportional equivalence between costs and benefits	High	Costs and benefits managed via community associations: Membership of a community association comes with financial and non-financial costs and benefits coordinated through the community association. (Costs include membership and pond licensing fees; fines (if applicable). Benefits include access to information; free laboratory testing of samples; partial compensation for financial losses, subsidies for disinfectants.
3: Collective-choice arrangements	High	Shrimp farmers' associations: At national level, all the community associations collectively participate in designing the annual crop calendar. At community level, members of the community association collectively participate in designing/modifying their daily operational rules/procedures.
4A: Monitoring rule enforcement	High	Community association and government institution: Farming operations are monitored throughout the culture cycle. This is done by the officers of community associations with the support of the government extension officers.

(Table 3: Continued)

Principle	Level of compliance with the principle	Description
4B: Monitoring state of resources	Moderate	External government institutions: Water quality of the common water body is monitored by government institutions (other than NAQDA). The common water body is monitored mainly by shrimp farmers themselves. Thirty-nine percent of the farms are family owned businesses; farmer and family members constantly observe changes taking place in shrimp ponds indicating disease.
5: Graduated sanctions	Moderate	Community association (depending on the seriousness of violation): Minor: ignorance or violation of rules related to better management practices can result in fines and/or non-issuance of the permit for a particular season. Very serious: legal actions are taken if used water from a disease-infected pond is released to the common water body.
6: Conflict resolution mechanisms	Moderate	Community association: Community association is the entity resolving the conflicts related to the common water body. Inter-community conflicts can go up to zonal or national level association(s). Issues are openly discussed during meetings to help resolve conflicts.
7: Minimal recognition of rights to organize	High	Collaborative decision making and bottom-up approach: Shrimp farmers and the government collaboratively work in making decisions. Government institutions do not challenge the community associations or the community rules. The Fisheries Act of Sri Lanka recognizes and promotes a bottom-up approach in managing the sector.
8: Nested enterprises	High	Multi-level institutional structure: Horizontally and vertically integrated institutions exist, mainly for decision making and information sharing purposes.

principle 1A, we had two components: “Do clearly defined boundaries exist?” And “Are these boundaries used for resource management purposes?” For principle 2A, we had four components: “Is there existence of congruence between rules and local conditions?”; “Are the rules restricting time?”; “Are the rules restricting place?”; and “Are there rules restricting technology?” For principle 6, we had two components: “Is there a mechanism for conflict resolution?” and “Is the mechanism effective?” Second, we assigned a score of 1 for the component of a principle which had negligible impact, a score of 2 for one that had some impact, and a score of 3 for a component that had a strong impact. Third, values were assigned for each component based on the field evidence and contextual understanding based on multiple evidence including meetings and interviews. Fourth, a value for the principle was calculated by averaging out the values for the components. A compliance level of “High” was assigned for a value of 2.5 or above; “Moderate” for values between 1.5 and 2.5; and “Low” for <1.5.

As Table 3 shows, the small-scale shrimp aquaculture case complies with all eleven design principles. The level of compliance is high with eight of the principles, and moderate with three of them (Principles 4B, 5 and 6). We did not find significant differences among the three communities.

4. Conclusions

How are the excludability and subtractability problems (Ostrom et al. 1999) resolved in northwestern Sri Lankan shrimp aquaculture? The excludability problem is dealt with in two main ways: (1) community associations have their own rules to control newcomers entering shrimp farming; and (2) the zonal crop calendar system (which is collectively developed by the shrimp farmers and the government) controls shrimp farmers accessing the common water body through rules that specify access in space and time. The subtractability problem requires dealing with the release of disease-infected water into the surrounding environment which affects the ability of other shrimp farmers to continue farming. The zonal crop calendar system provides a way of managing water intakes and discharges. Community associations play a major role in the development and implementation of this calendar system.

Based on the application of collective action design principles (Ostrom 1990; Cox et al. 2010), the shrimp aquaculture system in northwestern Sri Lanka is a success story, as the majority of the design principles (eight out of eleven) indicate a high degree of fit. Given that aquaculture often has a bad image (Pullin 2013) and gets blamed for various environmental and social impacts worldwide (Adger et al. 2005; Primavera 2006), it is important to find examples of aquaculture that work. Our case indicates that having a strong local commons institution is the key towards collective action. Community associations (*samithi*) are the main actors of the drama of the commons in the Sri Lanka case, ensuring the effectiveness of management at community level, facilitating sustainability in the long run.

However, sustainability is not merely about having a viable shrimp production system. It has other dimensions. In regards to social and economic dimensions as well, small-scale aquaculture seems to be sustainable, whereas big aquaculture apparently was not (it collapsed). Socially, community-based activities enable collective action and facilitate collaboration within and among communities, whereas in big aquaculture farmers tended to compete over resources. The zonal crop calendar makes small-scale aquaculture environmentally friendly, whereas big aquaculture developed disease problems. Small-scale farmers, embedded in their communities, do not have the option of abandoning their lands and moving elsewhere, whereas big aquaculture tended to move from one area to another. Further, in small-scale farms, benefits stay in the community. Women are the main harvesters of shrimp in both small and large-scale operations, but in small-scale farms, they are also active in bookkeeping and in farm management in general (Galappaththi and Berkes 2014).

Economically, small farmers do not need to make large profits to remain viable as big aquaculture does, in part because their overhead costs are small and family members often provide the labour (Galappaththi and Berkes 2014). Small-scale farmers have survived for 20 years or more, even when facing shrimp disease challenges. By contrast, large-scale aquaculture companies could not survive for more than 5 years. Small-scale community-based production seems to be steady over the years, unlike the boom-and-bust pattern of big aquaculture commercial production. All in all, the evidence suggests that small-scale aquaculture is sustainable, whereas big aquaculture was not.

The literature exploring sustainability in shrimp aquaculture has rarely used a commons approach (Lebel et al. 2002; Bush et al. 2010; De Silva and Davy 2010). Commons literature is poorly developed with regard to aquaculture; exceptions include studies of Vietnamese shrimp aquaculture (Armitage et al. 2011; Huong and Berkes 2011; Marschke et al. 2012) and collective management in Indian small-scale shrimp aquaculture (Umesh et al. 2010). Given that many resources in Sri Lanka are managed by commons institutions, our results are perhaps not surprising. For example, management of shore (beach) seine (*maa del*) fishery in western, southern, and eastern coasts of Sri Lanka is done by community-based co-management institutions (Samarakoon et al. 2011). The main resource managed in this case is marine fish. By contrast, the key resource in the northwestern Sri Lankan shrimp aquaculture is the water body, and not the shrimp.

The northwestern Sri Lankan shrimp aquaculture case provides some lessons in commons management. Following Ostrom principles, clearly defined boundaries; the collaboratively designed crop calendar, the bottom-up approach involving community associations, multi-level governance, and farmers-and-government collaborative structures are the key elements of the system. Together, these key elements resolve the excludability and subtractability problems of commons management by establishing boundaries and membership rules, and collective choice rules. Monitoring, enforcement/sanctions and conflict resolution, which are also part of resolving the subtractability problem, probably require more work and fine-tuning.

The government not only provides "minimal recognition of rights to organize" at the user level, it provides support and cooperation that provides *de facto* co-management, even though that term itself is not used in official Sri Lankan documents. The resulting system may be characterized as a mixed regime of commons management: privately owned shrimp farms, collective decision-making through cooperatives (*samithi*), and government facilitation, cooperation and oversight.

Complexities of shrimp aquaculture create difficulties in management (Bush et al. 2010) mainly because of uncertainty brought by shrimp disease. This Sri Lankan study addresses not only commons theory about mixed management regimes, but it also has conclusions applicable to a much larger regional situation. Small-scale shrimp aquaculture systems in various countries adapt different resource management approaches for resilience (Lebel et al. 2002). Even though other small-scale community-based shrimp aquaculture practices exist in South and Southeast Asia, it seems that they have not been documented to any extent. What are the viable institutional arrangements? How do other mixed regimes of private-communal-government (if any) work together? How does collective action come about? In addition to the water supply, what other kinds of commons may be important for collective management? How can national governments and international organizations best support sustainable small-scale shrimp aquaculture? What are the capacity-building needs? Our study opens the door towards examining other commons arrangements in aquaculture, regionally and internationally.

Literature cited

Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, and J. Rockström. 2005. Social-Ecological Resilience to Coastal Disasters. *Science* 309:1036–1039.

Alongi, D. M. 2002. Present State and Future of the World's Mangroves. *Environmental Conservation* 29(3):331–349.

Amarasinghe, U. S. 2010. Inland Fisheries Resource Enhancement and Conservation in Sri Lanka. In *Inland Fisheries Resources Enhancement and Conservation in Asia*, eds. M. Weimin, S. De Silva, and B. Davy, 113–128. Regional office for Asia and the Pacific, Bangkok: Food and Agriculture Organization of the United Nations.

Amarasinghe, U. S., W. U. Chandrasekera, and H. M. P. Kithsiri. 1997. Traditional Practices for Resources Sharing in an Artisanal Fishery of a Sri Lankan Estuary. *Asian Fisheries Science* 9(4):311–323.

Armitage, D., M. Marschke, and T. van Tuyen. 2011. Early-Stage Transformation of Coastal Marine Governance in Vietnam? *Marine Policy* 35(5):703–711.

Atapattu, A. R. 1987. Territorial Use Rights in Fisheries in Sri Lanka. Symposium on Exploitation and Management of Marine Fishery Resources in South Asia. *Indo-Pacific Fisheries Commission, RAPA Report 1987* 10:397–410.

Berkes, F., R. Mahon, P. McConney, R. Pollnac, and R. Pomeroy. 2001. *Managing Small-Scale Fisheries, Alternative Directions And Methods*. Ottawa: International Development Research Centre.

Bush, S. R., P. A. M. van Zwieten, L. Visser, H. Van Dijk, R. Bosma, W. F. De Boer, and M. Verdegem. 2010. Scenarios for Resilient Shrimp Aquaculture in Tropical Coastal Areas. *Ecology and Society* 15(2):15.

Campbell, B. and D. Pauly. 2013. Mariculture: A Global Analysis of Production Trends Since 1950. *Marine Policy* 39(2013):94–100. [Online] URL: http://www.sciencedirect.com/science/article/pii/S0308597X12002072.

Costa-Pierce, B. A. 2002. Sustainable Ecological Aquaculture Systems: The Need for A New Social Contract for Aquaculture Development. *Marine Technology Society Journal* 44(3):88–112.

Cox, M., G. Arnold, and S. V. Tomas. 2010. A Review of Design Principle for Community-based Natural Resource Management. *Ecology and Society* 15(4):38.

De Silva, S. S. and F. B. Davy 2010. *Success Stories in Asian Aquaculture*. Dordrecht: Network of Aquaculture Centres in Asia Pacific and Springer.

EJF. 2003. Smash and Grab: Conflict, Corruption and Human Rights Abuses in the Shrimp Farming Industry, Environmental Justice Foundation, London, UK, 2. [Online] URL: http://www.ejfoundation.org/pdf/smash_and_grab.pdf/.

Feeny, D., F. Berkes, B. J. McCay, and J. M. Acheson.1990. The Tragedy of the Commons: Twenty-Two Years Later. *Human Ecology* 18(1):1–19.

Food and Agriculture Organization (FAO). 2009. *The State of World Fisheries and Aquaculture (Sofia), 2008*. Rome, Italy: Food and Agriculture Organization of the United Nations.

Galappaththi, E. K. 2010. *Exploratory Study on Supply Chains of Cultured Prawns in Sri Lanka*. Peradeniya, Sri Lanka: Postgraduate Institute of Agriculture, University of Peradeniya.

Galappaththi, E. K. 2013. *Community-Based Shrimp Aquaculture in Northwestern Sri Lanka*. Winnipeg, Canada: Natural Resources Institute, University of Manitoba. [Online] URL: http://mspace.lib.umanitoba.ca//handle/1993/22107.

Galappaththi, E. K. and F. Berkes. 2014. Institutions for Managing Common-Pool Resources: The Case of Community-Based Shrimp Aquaculture in Northwestern Sri Lanka. *Maritime Studies* 13(1):13.

Gunawardena, A. and P. Steele. 2008. The Stake-Net Fishery Association of Negombo Lagoon, Sri Lanka: Why Has it Survived over 250 Years and Will it Survive Another 100 years? In *Promise, Trust and Evolution: Managing the Commons of South Asia*, eds. R. Ghate, N. Jodha, and P. Mukhopadhyay, 144–154. New York: Oxford Scholarship.

Hall, D. 2004. Explaining the Diversity of Southeast Asian Shrimp Aquaculture. *Journal of Agrarian Change* 4(3):315–335.

Hardin, G. 1968. The Tragedy of the Commons. *Science* 162:1243–1248.

Huitric, M., C. Folke, and N. Kautsky. 2002. Development and Government Policies of the Shrimp Farming Industry in Thailand in Relation to Mangrove Ecosystems. *Ecological Economics* 40(3):441–455.

Huong, T. T. T. and F. Berkes 2011. Diversity of Resource Use and Property Rights in Tam Giang Lagoon, Vietnam. *International Journal of the Commons* 5(1):130–149.

Lebel, L., N. H. Tri, A. Saengnoree, S. Pasong, U. Buatama, and L. K. Thoa. 2002. Industrial Transformation and Shrimp Aquaculture in Thailand and Vietnam: Pathways to Ecological, Social, and Economic Sustainability. *Ambio* 31(4):311–323.

Marschke, M., D. Armitage, L. V. An, T. V. Tuyen, and H. Mallee. 2012. Do Collective Property Rights Make Sense? Insights from Central Vietnam. *International Journal of the Commons* 6(1):1–27.

McCay, B. J. 1996. Common and Private Concerns. In *Rights to Nature: Ecological, Economic, Cultural and Political Principles of Institutions for the Environment*, eds. S. S. Hanna, C. Folke, and K. Maler, 111–126. Washington, DC: Island Press.

Munasinghe, M. N., C. Stephen, P. Abeynayake, and I. S. Abeygunawardena. 2010. Shrimp Farming Practices in the Puttallam District of Sri Lanka: Implications for Disease Control, Industry Sustainability, and Rural Development. *Veterinary Medicine International* 2010:1–6.

Nayak, P. K. and F. Berkes. 2010. Whose Marginalization? Politics around Environmental Injustices in India's Chilika Lagoon. *Local Environment* 15(6):553–567.

Nayak, P. and F. Berkes. 2014. Linking Global Drivers with local and Regional Change: a Social-Ecological System Approach in Chilika Lagoon, Bay of Bengal. *Regional Environmental Change* 14(6):2067–2078.

Naylor, R. L., R. J. Goldburg, J. H. Primavera, N. Kautsky, M. C. M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of Aquaculture on World Fish Supplies. *Nature* 405:1017–1024.

Ostrom, E. 1990. *Governing the Commons: the Evolution of Institutions for Collective Action.* New York: Cambridge University Press.

Ostrom, E. 2005. *Understanding Institutional Diversity.* Princeton: Princeton University Press.

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science* 325:419–422.

Ostrom, E., J. Burger, C. B. Field, R. B. Norgaard, and D. Policansky. 1999. Revisiting the Commons: Local Lessons, Global Challenges. *Science* 284: 278–282.

Ostrom, E., T. Dietz, N. Dolsak, P. C. Stern, S. Stonich, and E. U. Weber. 2002. *The Drama of the Commons*. National Research Council, Washington, DC: National Academy Press.

Primavera, J. H. 1997. Socio-Economic Impacts of Shrimp Culture. *Aquaculture Research* 28(10):815–827.

Primavera, J. H. 2006. Overcoming the Impacts of Aquaculture on the Coastal Zone. *Ocean and Coastal Management* 49(9):531–545.

Pullin, R. S. V. 2013. Food Security in the Context of Fisheries and Aquaculture – a Governability Challenge. In *Governability of Fisheries and Aquaculture: Theory and Applications*, eds. M. Bavinck, R. Chuenpagdee, S. Jentoft, and J. Kooiman, 87–100. Dordrecht: Springer.

Rose, C. 1986. The Comedy of The Commons: Custom, Commerce, and Inherently Public Property. *The University of Chicago Law Review* 53(3):711–781.

Samarakoon, J. I., M. Nightingale, R. Hermes, B. L. Joseph, and V. Salagrama. 2011. Review of Community-based Integrated Coastal Management: Best Practices and Lessons Learned in the Bay of Bengal, South Asia. 1–116. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN.

Umesh, N. R., A. B. C. Mohan, G. Ravibabu, P. A. Pandiyar, M. J. Phillips, C. V. Mohan, and B. V. Bhat. 2010. Shrimp Farmers in India: Empowering Small-Scale Farmers Through a Cluster-Based Approach. In *Success Stories in Asian Aquaculture*, eds. S. S. De Silva and F. B. Davy, 41–66. Dordrecht: Network of Aquaculture Centres in Asia Pacific and Springer.

Valiela, I., J. L. Bowen, and J. K. York. 2001. Mangrove Forests: One of the World's Threatened major Tropical Environments. *BioScience* 51(10):807–815.

Vlak, J. M., J. R. Bonami, T. W. Flegel, G. H. Kou, D. V. Lightner, C. F. Lo, P. C. Loh, and P. W. Walker. 2005. Nimaviridae. In *Virus Taxonomy. Eighth Report of the International Committee on Taxonomy of Viruses,* eds. C. M. Fauquet, M. A. Mayo, J. Maniloff, U. Desselberger, and L. A. Ball, 187–192. Amsterdam, The Netherlands: Elsevier.

Yin, R. K. 2009. *Case Study Research, Design and Methods* (4th ed.). Applied social research method series 5. Los Angeles: Sage Publications.