Chapter 5

Five key characteristics that drive commonisation

Empirical evidence from Sri Lankan shrimp aquaculture

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Introduction

The chapter examines five key characteristics that can drive commonisation in the face of social-ecological system change based on the case of Sri Lankan shrimp aquaculture. We argue that commonisation in shrimp aquaculture is possible when the five identified characteristics, or combinations thereof, create the atmosphere for establishing commons. We studied five small-scale shrimp farming communities in northwestern Sri Lanka. All coastal aquaculture in the northwestern region produces "black tiger shrimp" (*Penaeus monodon*). Sri Lanka is a small-scale shrimp producer in terms of quantity, but this case study provides unique insights into commonisation and its key characteristics. In Sri Lanka, from 1992 to 1996, the shrimp industry witnessed rapid and uncontrolled growth which resulted in a harvest of up to 8,000–9,000 kg/ha per year in large-scale classical earthen ponds (Galappaththi & Berkes, 2014). Yet, this growth couldn't be sustained due to resource mismanagement that led the industry into multiple disease outbreaks and environmental problems, including impacts from climate change. After 2005, shrimp aquaculture started moving in a positive direction under the ownership of small-scale producers and laid the foundation of Sri Lankan shrimp aquaculture commonisation – after a series of painful lessons learned from the past.

"Commonisation is understood as a process through which a resource gets converted into a jointly used resource under commons institutions that deal with excludability and subtractability, and "decommonisation" refers to a process through which a jointly used resource under commons institutions loses these essential characteristics" (Nayak & Berkes, 2011: 132). Obtaining a better understanding of the processes of both commonisation and decommonisation requires further examination of their characteristics. Such inquiries allow us to answer some critical questions, such as: How can shrimp aquaculture be managed as commons? What are the key characteristics of commonisation in the context of lagoon-based shrimp aquaculture? How do such characteristics support commonisation in the context of SES? Why is it important to understand such characteristics? Yet, most shrimp aquaculture literature concentrates on the wide range of adverse social and environmental implications resulting from unsustainable large-scale aquaculture (Benessaiah & Sengupta, 2014; Bhari & Visvanathan, 2018; Bush et al., 2010). The impacts of large-scale shrimp aquaculture are unpredictable and inequitable, as they depend on the level of vulnerability in a SES (Handisyde, Telfer, & Ross, 2017; Paprocki & Huq, 2018).

A limited number of scientific studies illustrates how to engage in sustainable shrimp aquaculture (Bush et al., 2010; De Silva & Davy, 2010; E. Galappaththi, 2013; Harkes, Drengstig, Kumara, Jayasinghe, & Huxham, 2015). For instance, Galappaththi and Berkes (2015) examined northwestern Sri Lanka shrimp aquaculture using an SES approach, focusing on the surviving small-scale shrimp farmers and how they creatively deal with uncertainties and complexities. Small-scale shrimp aquaculture operations have maintained close relationships with the environment, on which, along with natural resources, they depend for their livelihoods and well-being. With Sri Lanka's history of practicing community-based management and co-management of small-scale fisheries (for example, culture-based fishery) (Amarasinghe & Bavinck, 2017; De Silva, Amarasinghe, & Nguyen, 2006), an original research project was aimed at proposed community-based shrimp aquaculture as an alternative to large-scale aquaculture operations (Galappaththi, 2013). Galappaththi and Nayak (2017) used the story of Sri Lankan shrimp aquaculture to illustrate the two faces of shrimp aquaculture: commonisation and decommonisation. Collective action in the Sri Lankan shrimp aquaculture was used to illustrate the process of commonisation. Interestingly, even after the primary data collection in 2012, government statistics showed incremental improvement in aquaculture shrimp production since 2005. Almost all national shrimp aquaculture production comes from tiger shrimp farming in northwestern Sri Lanka (Figure 5.1).

Study area: Lagoon system

This study was conducted primarily in the five coastal communities of *Ambakandawila*, *Koththanthive*, *Muthupanthiya*, *Pinkattiya*, and *Karamba*, located in northwestern Sri Lanka. These shrimp farming operations rely on three different lagoon water bodies that provide a consistent water supply for shrimp farming – the *Chilaw* (700 ha), *Mundal* (3,600 ha), and *Puttalam* (32,000 ha) lagoon systems (Galappaththi & Berkes, 2015). Dutch Canal is a man-made canal that mainly connects the aforementioned three lagoons (Chandrasekara, Weerasinghe, Pathirana, & Piyadasa, 2018). Furthermore, this canal connects to several rivers and streams in the northwestern area, creating an interconnected system of common lagoon water body (Figure 5.2).

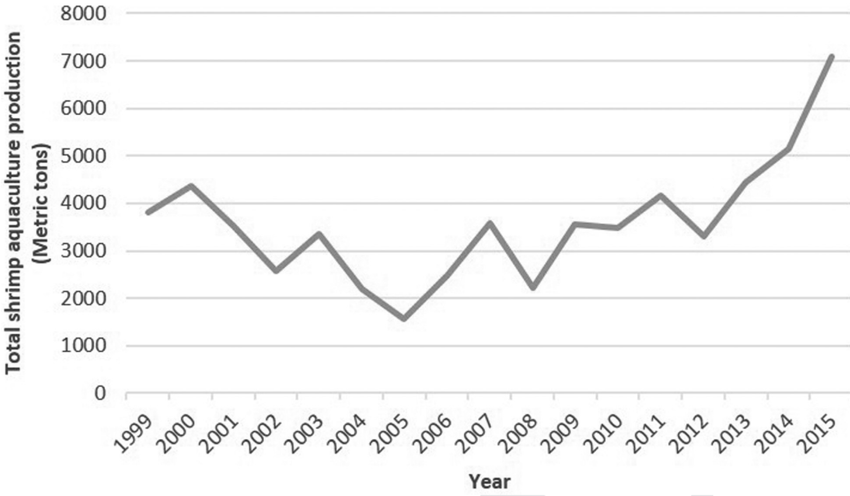

Figure 5.1 Total shrimp aquaculture production over the years (metric tons). A colour version of this image is downloadable as an eResource from www.routledge.com/9780367138004.

Data source: NAqDA (2017)

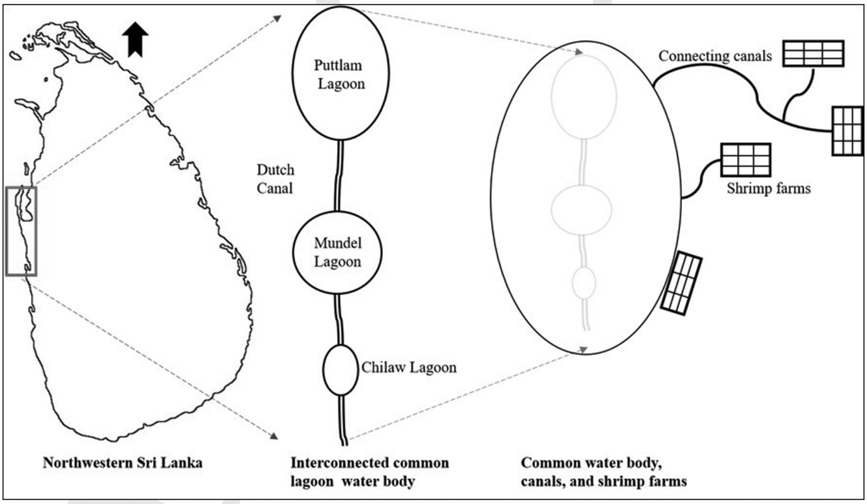

Figure 5.2 Sketch of the ponds and the canal/common water body where water is discharged/drawn. A colour version of this image is downloadable as an eResource from www.routledge.com/9780367138004.

Source: Adapted from Galappaththi et al. (2019a)

Almost all the shrimp farms in the northwestern coastal area are directly or indirectly connected to this water system. Hundreds of natural or man-made channels (inlet canals) and branches bring water to the shrimp ponds as well as drain excess/used water from them (outlet canal). Inevitably, all the shrimp farming operations in the northwestern area depend on this interconnected common water body (Galappaththi & Berkes, 2015).

The interconnected nature of the lagoon water system allows shrimp viral diseases to spread unpredictably. In addition, climate change impacts such as unexpected and extreme weather increase the uncertainty and complexities surrounding shrimp disease control. In the past, Sri Lankan shrimp aquaculture had experienced three major shrimp disease outbreaks (Galappaththi & Berkes, 2014; Munasinghe, Stephen, Abeynayake, & Abeygunawardena, 2010). The first major outbreak took place in 1988/9 and was due to the Monodon Baculo Virus (MBV). A second major disease outbreak occurred in 1996, causing White Spot Syndrome (WSS) in shrimp infected by the WSS Virus (WSSV). This was followed by a third outbreak in 1998, which was due to both WSSV and the Yellow Head Virus (YHV). WSS continues to remain as the largest threat to shrimp aquaculture in Sri Lanka. WSS infects mainly the penaeid shrimp species; it can act quickly and kill shrimp within a day. It can also spread quickly through other aquatic animals – crustaceans and birds – as carriers. Thus, shrimp diseases can quickly spread throughout the water system and to the shrimp farms that this water system connects, thereby directly affecting the livelihoods and well-being of small-scale shrimp farmers.

In this case study, we explain how shrimp farmers collectively respond to this shrimp disease challenge by managing the interconnected lagoon water body through a process of commonisation, which eventually led to establishment of aquaculture commons in Sri Lanka. The chapter's aim is to examine the characteristics of the commonisation process in Sri Lankan shrimp aquaculture. Proposed characteristics are major thematic areas that emerged during the qualitative data analysis ("manifest" and "latent" content analysis supplemented with "discourse" analysis). Data were collected using participant observations, interviews, and focus groups during 2012–2013. The authors considered some insights from the first author's experience as a shrimp farmer in the same region during the transition of shrimp aquaculture management in Sri Lanka (2003–2006). The following section discusses this commonisation by first exploring the sample profiles, then by covering the history and development of Sri Lankan shrimp aquaculture. Third, the chapter explains the Zonal Crop Calendar system through which shrimp farmers manage aquaculture resources as commons following their multi-layered institutional structure. Next, under discussions and conclusion, the chapter covers five characteristics that drive commonisation in facing SES change, including climate change.

Sample profile

Almost all existing shrimp aquaculture operations in northwestern Sri Lanka were small-scale (Galappaththi & Berkes, 2015). Recorded pond size varied from 0.2 to 0.8 hectares and total farmland area varied from one to seven hectares. Farmland ownership varied among farmers. Fifty-three percent of farms were on state-owned lands while 37 percent were farmer-owned. There were some unresolved legal issues, related mostly to the use of state-owned lands for shrimp farming. The remaining 11 percent of farmers rented land from previous shrimp farmers. Forty-two percent of farmers carried out farming activities on their own. While 39 percent of farms were family-owned businesses, 11 percent were organised through partnerships. Eight percent of farmers operated their businesses as private limited companies.

Farmers' general practice was to employ the minimal number of employees to reduce input costs. Forty-seven percent of farms employed two to five people; 24 percent had fewer than two employees; and 29 percent employed five to eight people. The involvement of family members in farming operations was a common phenomenon due mainly to the high input cost of farming, which was the main factor limiting the ability to hire more people. Seventy-four percent of farmers said that they received family support. Sixty-four percent of farmers received family support from women – wives, daughters, mothers, and/or other close relatives. These women were involved in diverse ways: labour (shrimp harvesting), bookkeeping, day-to-day farm administrative activities, financial contributions towards farming (investment), and participation in the community association activities.

Famers also had multiple revenue streams, arguably a way to manage livelihood risk (Galappaththi, Galappaththi, & Kodithuwakku, 2017). Fifty-eight percent of the farmers engaged in a secondary income-generating activity. Some of these activities were related to shrimp aquaculture: shrimp post larvae production, shrimp feed sales, and shrimp and fish integrated farming. Lagoon-based capture fishery, salt production, and the cultivation of coconut, paddy (rice), and vegetables were additional livelihood activities undertaken other than shrimp aquaculture.

History and development of Sri Lankan shrimp aquaculture

At present, the major activity in these lagoon water bodies is shrimp aquaculture. Lagoon capture fishery still exists in the area, but at a negligible scale. Sri Lankan shrimp aquaculture operations began in the late 1970s with four multi-national companies (Andrew's, Carson, Enris, and Liver Brothers) operating as commercial scale ventures. Initially, these farms were geographically limited to the eastern part of the country (the Batticaloa District). These companies reportedly earned high profits partly due to their technical know-how with respect to aquaculture systems, input supply, and marketing, which was not accessible by anyone from the outside.

Before the 1980s, lagoon capture fishery dominated lagoon water bodies in the northwestern coastal belt. Villages used to fish for shrimp and fin fish mainly for subsistence purposes. These fishers used wooden fishing canoes and various fishing gears, such as cast nets, gill nets, and other traditional fishing equipment. In the early 1980s, some of the employees of pioneer shrimp farming companies started their own farms to practice what they had learnt while working for large-scale operations by companies. The profit-making potential of shrimp farming attracted new investors, such as politicians, bank managers, and wealthy business owners.

In the early 1990s, the Sri Lankan government started promoting shrimp aquaculture as a profitable self-employment opportunity among locals in the northwestern coastal area. Many community-level small-scale farmers started shrimp farming, leading to an expansion of shrimp aquaculture throughout the northwestern coastal area. Small-scale farmers continued farming within the same community area while large- and medium-scale farmers shifted from place to place by converting mangrove and coconut cultivation lands into shrimp farms. The civil unrest that prevailed in the eastern part of the country limited the industry's expansion to that area.

In the late 1990s, as small-scale shrimp farming operations rapidly grew, farmers across the northwestern area began organising into associations. This led to the emergence of community-based institutions. In terms of shrimp production volumes and quality standards, the government or any other regulatory body had no control over the industry. For instance, no specific timeframe existed for stocking shrimp post larvae (baby shrimp or seed). Shrimp farmers and hatcheries continued their production throughout the year, and no rules were in place to govern the starting or closing of farming operations. Post larvae producing shrimp hatchery owners self-organised into a shrimp breeders' association as a means of sharing technical knowledge and obtaining better selling prices for post larvae.

In the early 2000s, the shrimp breeders' association took the initiative of calling a meeting of all the stakeholders in the shrimp aquaculture sector to develop a strategy for overcoming the industry's difficult position. In 2005, these discussions resulted in the formation of a national-level sector association called SLADA (Sri Lanka Aquaculture Development Association), in collaboration with all the industry stakeholders. SLADA asked the Ministry of Fisheries to form a government institution responsible for supporting and monitoring the northwestern shrimp aquaculture sector. In 2003/4, the Sri Lankan central government was directly involved in the supervision of the shrimp aquaculture sector through a line institution called the National Aquaculture Development Authority of Sri Lanka (NAqDA). NAqDA's approach was to work in collaboration with SLADA, community-level shrimp farmers' associations, and shrimp breeders' associations. One of the initial tasks of the SLADA and NAqDA collaborative management arrangement was to respond to the shrimp disease problem.

In 2005/06, SLADA designed and introduced a Zonal Crop Calendar (ZCC) to control access to the natural lagoon water body for purposes of managing shrimp diseases. NAqDA's role in the implementation of ZCC was to coordinate, monitor, and facilitate the implementation process. The crop calendar significantly changed the way in which farming operations were conducted in the area. Initially, the historically independently operated people of the sector (especially farmers and breeders) had trouble adjusting to the new management system. They resisted mainly due to the limited number of production cycles allowed per year. During the first few crop cycles under the new ZCC system, some relatively large- and medium-scale shrimp farmers and hatchery owners left the industry after realizing that it would not be profitable to keep their farms and hatcheries in an idle state during some parts of the year.

Farmers and hatchery owners who adapted to the Zonal Crop Calendar experienced a successful year mainly in terms of controlled disease spread. This success story caused some of the previous farmers (those who had left shrimp farming) to resume farming during the following season. However, the next season was less successful in terms of shrimp production and selling prices. Most of the medium-scale farmers stopped farming because of the uncertain nature of production as well as the significant increase in labour costs and inputs such as fuel and chlorine. White Spot Syndrome, which had been assumed to be under control, returned from time to time, resulting in fluctuations in shrimp production and prices.

By 2009/10, most farmers and hatchery owners who remained in the industry were abiding by the ZCC system. NAqDA worked towards strengthening the existing community-level associations. NAqDA became more flexible in its approach towards learning from previous experiences, and the shrimp farmers started cooperating. All the changes that had taken place during the previous stages resulted in the establishment of a multi-layered management structure. After years of battling shrimp diseases, about 600 shrimp farms remained in northwestern Sri Lanka by 2012.

Zonal Crop Calendar (ZCC)

ZCC is a self-protective approach towards managing shrimp diseases, implemented in northwestern Sri Lanka (Galappaththi & Berkes, 2015). The uncontrollable nature of shrimp disease conditions and the resulting impacts on the industry led to the development of a crop calendar. SLADA introduced it in 2004 and its implementation was legalised by the Ministry of Fisheries and Aquatic Resources Development in Sri Lanka. The crop calendar's main objective was to minimize the damage caused by shrimp diseases (mainly WSS disease) to increase national-level shrimp production. Zonal and sub-zonal geographical boundaries were developed that considered the connected nature of the area's natural water system and the shrimp disease spreading patterns through the lagoon water body. One (or two) shrimp farming communit(ies) was (were) recognised as a sub-zone and a collective of sub-zones became a zone. Thus, the northwestern shrimp farming area was divided into 5 zones and 32 sub-zones (Figure 5.3).

ZCC provides an annual plan for water allocation for shrimp farming in the northwestern area. SLADA/shrimp farmers and the government collectively decide which zone(s) and/or sub-zone(s) can access the interconnected common water body for shrimp farming during each crop season. A commonly agreed-upon annual crop calendar is designed and implemented. In other words, consensus is achieved regarding who can engage in shrimp farming during a season and who cannot. A calendar year is divided into three seasons of shrimp production: pre-*yala* (February to April); *yala* (April to September); and *maha* (October to February). Production seasons are

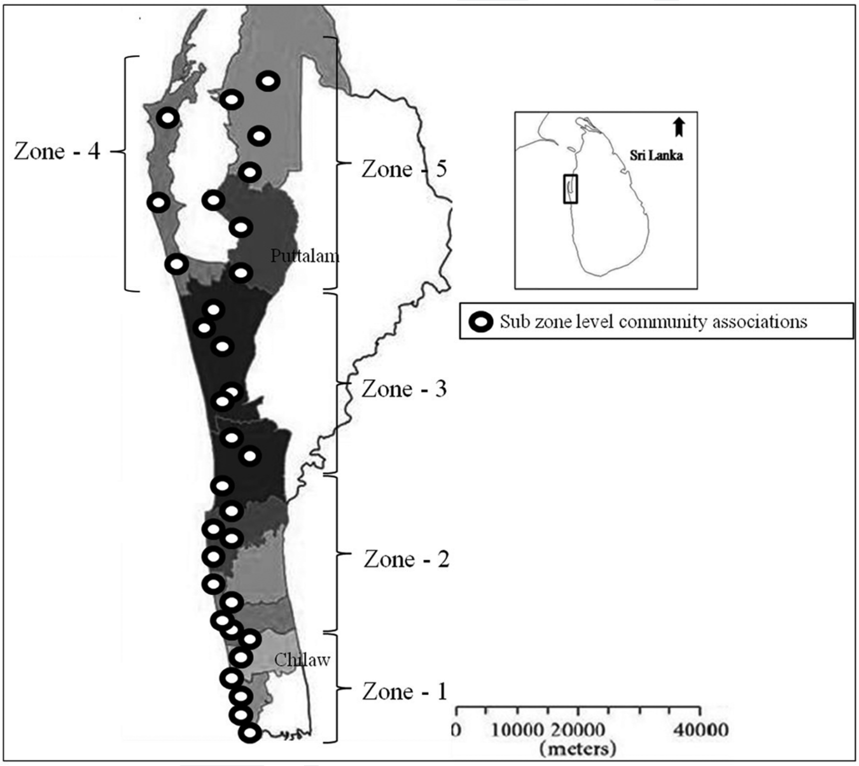

Figure 5.3 Map of the Zonal Crop Calendar boundaries. A colour version of this image is downloadable as an eResource from www.routledge.com/9780367138004.
Source: Adapted from Galappaththi and Berkes (2015)

assigned to sub-zones/communities based on the disease spread patterns along the water system. Each community receives at least one or two production season(s) per year. This way, the seasonal crop calendar creates buffer zones through geographical (zones/sub-zones) and temporal (seasons) boundaries. Furthermore, the ZCC is subjected to changes on an annual basis – an adaptive learning process. Changes are made based on feedback from farmers escalated through the multi-layered structure and from lessons learned during previous crop seasons responding to the changing climate. ZCC is the most significant component of the existing governance system, as it determines all the other activities related to shrimp farming, such as post larvae production and quantities.

As part of the ZCC system, community institutions practise Better Management Practices (BMPs) for shrimp aquaculture operations. BMP is a set of guidelines that NAqDA developed for adaptation at the community level. For example, BMPs specify a stocking density reliant on the use of aerators, i.e., four to six post larvae/m^2 for a pond with no aerators and a maximum of 10 post larvae/m^2 for a pond with aerators. Community associations are expected to adapt and fine tune these BMPs to suit their own environments and social conditions, such as salinity levels (which affect the use of aerators), the availability of mangrove vegetation closer to farms, and the success of previous crops. The multi-layered institutional structure reinforces the shrimp aquaculture governance system.

Multi-layered institutional structure

The Sri Lankan shrimp aquaculture production system is managed by a multi-layered institutional structure that, since the 1990s, has evolved from less complex community associations (Figure 5.4). This is a private-communal-state mixed management regime. At the heart of this mixed regime is the community-based institution (called *samithiya* in the local language), i.e., the shrimp farmers' association. These community-based institutions together serve as the bottom (community) level, self-organised community entities within the hierarchy of existing shrimp farmers' associations (community to national level). Community-level shrimp farming associations formulate and implement their own rules to manage community-level resources. Every shrimp farmer in the community (100 percent) must be a member of the community association. Most of the community associations are small collective groups (20 to 60 members). The elected officers of a community association include the president, vice president, secretary, treasurer, and assistant treasurer. Most of the community associations have government aquaculture extension officers that work closely to ensure that practices comply with national regulations. However, these officers do not have the power to influence any of the decisions that the associations make. The community-level rules for managing shrimp aquaculture practices/resources are created through collective

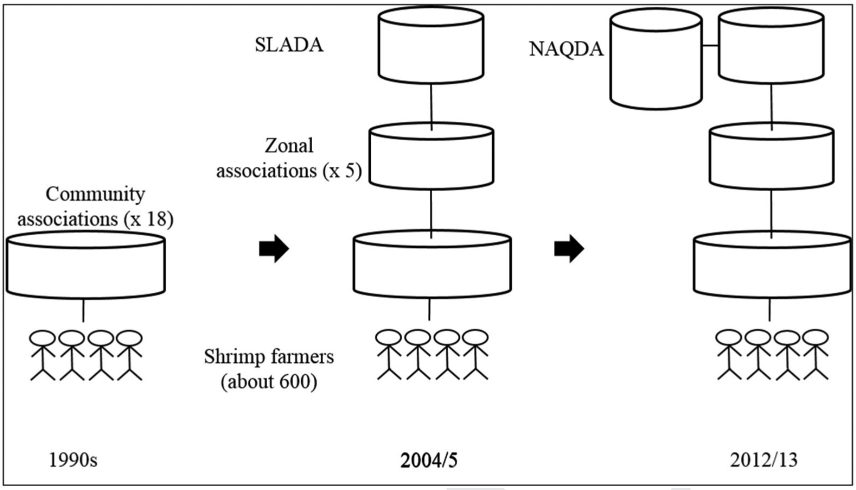

Figure 5.4 Adapting commons institutions. A colour version of this image is downloadable as an eResource from www.routledge.com/9780367138004.

Source: Adapted from Galappaththi et al. (2019a)

decisions. The collective decision-making process is one of the important characteristics of a community association. The community association also acts as an information hub by sharing information about shrimp aquaculture operations among member farmers. Such information includes post larvae prices; feed brands/prices; farm gate shrimp (harvest) prices; production quotas and stocking dates based on the national crop calendar; disease prevalence/spread; and shrimp farming techniques and management practices.

Community-level institutions are well-organised and interconnected through overriding zonal-level associations. Some zonal associations represent just one sub-zone, whereas the others may represent up to eight sub-zones. While the community associations are represented by community-level shrimp farmers, leaders of these sub-zonal associations represent the zonal association. All the zonal associations and sub-zonal associations are collectively represented in SLADA – there is at least one representative from each zone and sub-zone.

SLADA, the national-level association representing all the direct stakeholders in the shrimp farming sector – farmers; hatchery owners; feed suppliers; and shrimp processors – was established in 2005 with an initial membership of 16 people. Later, zonal and sub-zonal associations were granted permission to become members of SLADA. Consequently, the membership increased to about 50. To improve the shrimp farming sector, SLADA appointed six committees that targeted different subject areas, such as environmental protection, hatchery development, and shrimp farm development. Furthermore,

Table 5.1 Roles and responsibilities of each management level

Level	*Specific Roles and Responsibilities*
Community-level associations (samithi)	To regulate community-level farming practices with the support of NAqDA field extension officers. For this purpose, there is a shrimp farm monitoring and extension unit in Battulu Oya (established in 2008).
Zonal associations	To develop the infrastructure of shrimp farming areas in collaboration with divisional secretariat offices and provincial councils. Zonal associations also maintain a link (mainly communication) between the sub-zonal and national levels.
SLADA and NAqDA collaboratively	To improve the performance of the overall national-level shrimp aquaculture system. In this role, the management body has the authority to take legal action in response to any illegal activities, such as shrimp post larvae stocking beyond the crop calendar and the release of disease-infected water into the natural water body.

SLADA and NAqDA jointly developed a Technical Advisory Committee representing expertise from local universities and research institutions.

SLADA and NAqDA collaboratively form the top layer of the management structure. It is a joint management body and the decision-making pattern is a participatory process. The most interesting feature of this top management body is its composition; SLADA includes representation from all the stakeholders while NAqDA brings the government authority to the table. This body is powerful and effective at formulating as well as implementing guidelines to better regulate and ensure the industry's sustainability. Its ability to influence community-level actions and compliance is due mainly to the participatory nature of making decisions and creating guidelines. Furthermore, each layer of the management structure is tasked with specific roles and responsibilities (Table 5.1).

Major changes in the shrimp aquaculture management system over time (i.e., the time before and after implementation of the ZCC system) influence the lagoon SES. The lagoon has many other resource users besides shrimp farmers (e.g., fishers, gleaners, salt farmers, and hotels and tourism). Lagoon resource stakeholders express dynamic viewpoints about how major changes in shrimp aquaculture management have affected their lagoon-related livelihood activities (Table 5.2).

Discussion

The connected nature of the three lagoon water bodies and Dutch Canal has a large impact on Sri Lankan shrimp aquaculture management. Shrimp disease spreading along this common water body represents the key challenge

Table 5.2 Dynamics and critical perspectives resulting from commonisation of shrimp aquaculture

Lagoon Resource Users	*Quotes*
Salt farmer from Puttalam Lagoon	… I used to be a shrimp farmer … now I'm using my abundant shrimp ponds for salt farming …
Cast-net fisher from Mundel Lagoon	… we have a different samithi [cooperative] to discuss our [lagoon fishers] matters … It's hard to live now … it's a matter of survival … as long as I and my family survive, that is what I think about. My friends [fishers] already moved to other jobs in off-show trawling and seasonal labour in shrimp farm[s] …
Tourist guide working in lagoon-based eco-tourism	… this [hotel in the lagoon area] is fine, but there are some other places [lagoon area] [that need] dredging and cleaning … water is not flowing well … it's going to be worse in [the] coming rainy season. We don't get many people [tourists] that time [monsoon season].
Broker/middleman for selling land/ shrimp/fish	… land prices [around Chilaw Lagoon] are increasing every day … sometimes foreigners are also looking [to buy] land … shrimp price margins are not attractive anymore … we can't make good money like in the early days [before 2000] … actually, they don't produce much shrimp now …

facing shrimp farmers. Shrimp farmers have self-organised with government support and have implemented a calendar system to manage shrimp disease impacts. Arguably, this interconnected common water body acts as a common-pool resource. The ZCC is essentially a way of responding to shrimp disease challenge and creating aquaculture commons (Galappaththi & Berkes, 2015). The ZCC system addresses the excludability problem in commons theory (Ostrom, 1990), as it controls access to the common water body.

The second method of addressing the problem of excludability is through community-based institutions (*samithi*) (Galappaththi & Berkes, 2014). Individually owned farms are managed under community-level rules. Community-level shrimp farmers' associations collectively establish their own rules to avoid movable shrimp farming. These rules deny access to outsiders. The subtractability problem in shrimp aquaculture is associated mostly with the discharge of used pond effluents (Galappaththi & Berkes, 2015). A farmer may release disease-infected water from a shrimp farming pond into the surrounding environment (to an interconnected lagoon water body). This action affects the ability of other shrimp farmers to continue farming without being infected by shrimp diseases which can affect their livelihoods.

This chapter shows how shrimp farmers have experienced SES change, how they have responded to such changes, and how they are undergoing the process of commonisation. Commonisation is a complex process (Nayak & Berkes, 2011), but in this chapter we recognise its five vital characteristics, including essentials based on the case of Sri Lankan shrimp aquaculture: (1) bottom-up multi-level institutions with a mixed commons governance regime; (2) collaboration and collective action among resource users to share uncertainty and common challenges; (3) partnerships and government support for the commons governance system; (4) an adaptive nature throughout the commons governance process; and (5) effective networking and information sharing through commons institutions. Table 5.3 shows how such characteristics drive commonisation in the context of community-based shrimp aquaculture.

Table 5.3 Five key characteristics of community-based shrimp aquaculture that can drive commonisation

Key Characteristic	*Description/How It Enables Commonisation*	*References*
Bottom-up multi-level institutions with a mixed commons governance regime	Multi-level institutional structures will integrate all the organised commons institutions at all levels (community, zonal, and national) to enable better decision making related to shrimp aquaculture management (for example, the annual crop calendar). The bottom-up approach allows feedback (for example, updates about past crop and disease conditions) to be obtained from community-level to national-level decision making for ZCC development. A mixed commons governance regime (private, communal, and government) brings diversity and a broad range of knowledge to the overall institutional structure while improving the effectiveness of decision making. A multi-level institutional structure plays a key role in the process of commonisation by adjusting to changing SES.	(E. K. Galappaththi & Berkes, 2014)
Collaboration and collective action among resource users to share uncertainty and challenges	Shrimp farmers co-operate with each other by working collaboratively/collectively to overcome shared challenges (mainly shrimp diseases). Collaboration happens at multi-levels involving diverse interest groups. For instance, the shrimp farmers' association facilitates community-level collaboration and collective action among shrimp farmers (e.g., shrimp harvests, disease situations, charity work). At the national level, the joint body of the government (NAqDA) and the sector association (SLADA) collaborate on annual ZCC planning, with the representation of all zonal and community levels. Competition over scarce resources is typical and broadly occurs all over the world, leading to the process of decommonisation. Collaboration and collective action can facilitate the process of commonisation.	(E. Galappaththi & F. Berkes, 2015; E. K. Galappaththi & F. Berkes, 2015)

(*Continued*)

Table 5.3 Cont.

Key Characteristic	*Description/How It Enables Commonisation*	*References*
Partnerships and government support of the commons governance system	Decision making at all levels follows a participatory approach. This involves the participation of regional, provincial, and central government institutions and academic institutions for ZCC planning. The ZCC is developed by the shrimp farmers with the support of the government. The government facilitates the mainstreaming of the commons management system (for example, registering community associations, providing technical know-how, monitoring the ZCC system, providing capacity-building programs). Farming operations are owner-managed under community-level rules, with government oversight and coordination. Though no formal co-management arrangement exists with the government, the small-scale aquaculture practiced in Sri Lanka since 2012 is de facto co-management. Overall, government support and partnerships can be used throughout commonisation.	(E. K. Galappaththi & F. Berkes, 2015)
Adaptive nature throughout the commons governance process	First, adapting institutions (Boyd & Folke, 2012), from community associations to multi-level institutional structures, allows for adaptation to the changing SES conditions over the years (Figure 5.4). Second, ZCC is an adaptive process, as the annual ZCC continually changes according to the prevailing SES conditions, such as disease dominant (sub)zones, the changing climate, and extreme weather events. Third, BMPs are used based on the prevailing conditions in the communities (e.g., lagoon salinity levels, availability of mangrove forests). This adaptive nature allows for improved updates in response to changing conditions as a means of supporting the process of making commons.	(E. Galappaththi, Berkes, & Ford, 2019b; E. K. Galappaththi & F. Berkes, 2015)
Effective networking and information sharing through commons institutions	Effective networking takes place with relevant stakeholders in a shrimp aquaculture supply chain and specific information (e.g., related to disease and price) is shared among such stakeholders through community associations. According to Galappaththi et al. (2019b) when shared broadly and available readily, information can behave as commons – information commons. Information commons can enable commonisation, as a positive correlation exists among effective information sharing, the functionality of community associations, and the overall performance of the small-scale producers' supply chains.	(E. Galappaththi et al., 2019b)

The aforementioned five characteristics of resource governance in small-scale coastal aquaculture can be recognised as different but interrelated means of driving commonisation in shrimp aquaculture. These characteristics, in different combinations, allow for commonisation under specific SES conditions. However, we are not arguing that the shrimp aquaculture governance in Sri Lanka is perfect in terms of equitable distribution of benefits among farmers; power imbalances inherent in the process can affect SES resilience (Bournazel et al., 2015; NAqDA, 2017). Still, the overall effectiveness of the ZCC system and the methods of building commons in this aquaculture system are reflected in the sustainability of – and gradual increase in – aquaculture shrimp production (Figure 5.1). Furthermore, based on the application of collective action design principles (Cox, Arnold, & Tomás, 2010; Ostrom, 1990), the shrimp aquaculture management system in northwestern Sri Lanka is a success story, as most of the design principles (eight out of eleven) indicate a high degree of fit (Galappaththi & Berkes, 2015).

Commonisation and decommonisation are two faces of shrimp aquaculture (Galappaththi & Nayak, 2017). To better understand the process, it is important to understand the characteristics and aspects that drive each face. Ultimately, the two faces of shrimp aquaculture can be identified in the same SES. For instance, before commonisation, Sri Lankan shrimp aquaculture underwent the process of decommonisation. This decommonisation process had its origin along with the beginning of large-scale aquaculture (late 1970s), when shrimp aquaculture expanded across the northwestern coastal areas through the conversion of coconut lands and mangrove forests into shrimp farms. This aggressive expansion of aquaculture disturbed and encroached into lagoon space for capture fisheries. Shrimp disease outbreaks were the result of a decommonisation process that led shrimp farmers to create the ZCC system. The introduction of this system, coupled with the collective action of individual owners through cooperatives and a collaborative multi-level management structure, caused the shrimp aquaculture system to undergo the process of commonisation. Because of this persistent process, shrimp aquaculture SES has become much more resilient. Examination of the characteristics of the two faces of aquaculture advances the knowledge necessary to address issues of theoretical significance for aquaculture governance and policy development (Krause et al., 2015), as well as of practical significance for sustainable aquaculture (DeBey, Foco, & Alder, 2017).

While shrimp aquaculture goes through a process of commonisation, the lagoon SES indicates dynamic critical perspectives (Table 5.2). For example, a number of sub-systems (or resource users) – such as lagoon fishers, salt farmers, mangrove eco-systems, and lagoon-based tourism – that rely on the interconnected lagoon waterbody report how the lagoon system has changed with shrimp aquaculture. Arguably, the "commonisation" process of small-scale shrimp farmers might have led to the "decommonisation" of the resource base of small-scale capture fishers and/or gleaners. As such, the use of the term "commonisation" for lagoon SES could be challenged. In this case, "decommonisation" may be inherent to the process of "commonisation". However, in reality, use of the ZCC system evidently minimizes adverse impacts on the lagoon system as compared to the pre-ZCC era (a time of the "decommonisation" of shrimp aquaculture). This highlights the importance of studying and understanding the "big picture" of lagoon SES as a process using commons and SES perspectives.

In an aquaculture commons, the impacts of climate change affect the process of commonisation. Climate change impacts, such as unexpected weather and extreme events (for example, floods and droughts), increase the uncertainties and complexities of shrimp disease control and the ZCC system. The ZCC system is the prime mechanism for building resilience in the face of the challenges that shrimp disease poses. Crop calendar planning is based on the prevailing shrimp disease in the lagoon, while weather predictions rely on past weather experiences. Furthermore, unexpected climate change limits the effectiveness of BMPs as shrimp farmers modify and adapt best management practices, as appropriate, to community conditions. However, shrimp farmers seeking to manage the complexities and uncertainties created by climate change use a learning-by-doing approach (adaptive management) to practice ZCC. From a social-ecological resilience perspective (Berkes, Colding, & Folke, 2003), unexpected and extreme weather increases the uncertainties and complexities of northwestern shrimp aquaculture SES. Galappaththi et al. (2019b) illustrate how the ZCC system's implementation is supported by the system resilience, which are: living with change and uncertainty (shrimp disease and weather changes); nurturing diversity (non-aquaculture livelihood options); using different kinds of knowledge (shrimp production techniques, marketing knowledge, local environmental knowledge); and fostering learning (collective learning via *samithi*). Thus, such sources of resilience (Folke, 2016) are positively corelated with the performance of commonisation.

Conclusions

The geographical context of an aquaculture system (for example, the interconnected nature of a lagoon system) can be an important aspect to consider in the process of making commons, i.e., commonisation. ZCC is an innovative way to create aquaculture commons in the context of lagoon-based aquaculture. Environmental and climate change can increase the uncertainties and complexities related to commons governance. Based on Sri Lankan shrimp aquaculture, the five key characteristics that drive commonisation in the face of SES change are: bottom-up multi-level institutions with a mixed commons governance regime; collaboration and collective action among resource users to share uncertainties and challenges; partnerships and government support for the commons governance system; an adaptive nature throughout the commons governance process; and effective networking and information sharing among commons institutions. These key characteristics, combined with the sources of resilience, can help shrimp aquaculture persevere (i.e., remain sustainable) because commonisation can make such SES adaptive and resilient to change.

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