Making Shrimp Economies and Hydro-Social Lives: The Hatchery, the Shrimp Farm, and the Laboratory in the Mekong Delta

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Abstract

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Yu-Kai Liao

This thesis explores the formation and operation of shrimp economies that bring together multiple species and their ecological conditions of production through capitalist and more-than-capitalist relations in contexts of agrarian, technical, and environmental changes. It focuses on the Mekong Delta in Vietnam, where due to climate change and salinity intrusion, farmers and companies are shifting from growing rice to breeding shrimp in an effort to adapt to climate change and help alleviate poverty. These strategies of adaptation and livelihood, however, also have effects on delta ecologies and economies. The research draws these dynamics together at the intersection of water and society, or hydro-social life, to examine different sites amid the history of water management in the Mekong Delta. Multi-species and multi-sited ethnography were conducted, following shrimp through the hatchery, the shrimp farm, and the laboratory within and beyond the Mekong Delta.

This research argues that shrimp economies, as a form of bioeconomy, are formed and constructed by organising hydro-social lives across three sites: (1) shrimp reproduction in the hatchery, (2) shrimp growth on the farm, and (3) scientific research in the laboratory. Hydro-social lives assemble and reassemble water-shrimp-human-environment relations to create the material basis of shrimp production. Meanwhile, hydro-social lives involve both capitalist and more-than-capitalist relations, which drive significant agrarian, technical, and environmental changes to farmers and capitalists within and beyond the Mekong Delta.

This study makes three original contributions. First, it extends work in political economy and political ecology on the socio-natural organisation of commodity production by analysing the materiality of shrimp production, and capitalist and more-than-capitalist relations in bioeconomies. Second, it contributes to water research by examining how water-shrimp-human-environment relations are integral to the production of aquatic animals. Third, it unfolds hydro-social life in the hatchery, the delta, and the laboratory to examine these complex and dynamic relations in different environments, contributing to delta studies and STS.

Statement of Copyright

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ATRI	Agricultural Technology Research Institute
CfM	Care for Mangrove
DSCAM-1	Down syndrome cell adhesion molecule 1
EMS	Shrimp Early Mortality Syndrome
FAO	Food and Agriculture Organization of the United Nations
FMB	Forest Management Board
GEP	Global Environment Facility
GSMFC	Gulf States Marine Fisheries Commission
JCRR	Joint Commission on Rural Reconstruction
PCR testing	Polymerase chain reaction testing
SIS	Shrimp Improvement Systems
SPF shrimp	Specific-pathogen-free shrimp
SPF larvae	Specific-pathogen-free larvae
WSS	White Spot Syndrome

Chapter 1 Introduction

This dissertation explores shrimp economies as a form of bioeconomy that bring together multiple species, including humans, and their ecological conditions of production, across multiple sites through capitalist and more-than-capitalist relations to develop shrimp aquaculture in a context of agrarian, technical, and environmental changes. It proposes and develops the concept of hydro-social life to examine how water-shrimp-human-environment relations are articulated to underpin the operation of shrimp economies across multiple sites. I conducted 12 months of ethnographic work to trace shrimp in the hatchery, the delta, and the laboratory in Vietnam. This research contributes to: (1) political economy and political ecology on the socio-natural organisation of commodity production by bringing together shrimp lives and social lives through capitalist and more-than-capitalist relations, (2) the notion of hydro-sociality in water research by examining how water quantity, quality, and ecologies shape the formation and operation of bioeconomies, and (3) science and technology studies and delta studies by unpacking commodity production and multi-species relations across three sites — the hatchery, the delta, and the laboratory.

Shrimp is a newcomer to the farm. In 1934, Kuruma shrimp was first domesticated and artificially propagated by Dr Motosaku Fujinaga, a Japanese scientist. There are now around 2,000 species of shrimp in the world. Yet, in the history of shrimp domestication, only black tiger shrimp (*Penaeus monodon*), whiteleg shrimp (*Litopenaeus vannamei*), giant freshwater shrimp (*Macrobrachium rosenbergii*), and brine shrimp (*genus Artemia*) are domesticated and have sufficient commercial value to be industrially grown. In the Mekong Delta, shrimp farming has been practised for about 100 years but modernised since the 1980s (Luong et al., 2002). From the 1980s, banana shrimp (*P. merguiensis*) and Indian white shrimp (*P. indicus*) were the main cultivated species, then from 1997 and 2000 replaced by black tiger shrimp and whiteleg shrimp because of their faster growth rate and a larger global market (Shrimp News International, 2015).

In 2013, the Vietnamese government announced *The Master Plan on Fisheries Development of Vietnam to 2020, Vision to 2030* (Decision No. 1445/QD-TTg) to raise the status of shrimp farming in the Mekong Delta and to boost shrimp exports by embracing international markets (The Voice of Vietnam, 2017; Nguyen et al., 2019). From 1995 to 2017, production from shrimp aquaculture in the Mekong Delta increased 12-fold, from 47,121 to 598,690 tons (General Statistics Office of Vietnam, 2017). In Vietnam, as elsewhere in Southeast Asia, shrimp aquaculture is increasingly overtaking traditional rice farming in coastal deltas in tropical climates, such as the Mekong Delta and the Ganges delta.

Due to climate change and salinity intrusion, the Mekong Delta is now affected by salinity for more than six months a year, resulting in the death of rice seedlings and subsequent poverty for farmers (Toan, 2014). In 2016, Vietnamese rice farmers suffered from a severe drought related to El Niño. As a result, they did not have enough freshwater to irrigate their rice seedlings, relying instead on salty river water. This environmental change provided an ecological impetus for commercial shrimp farming, which requires carefully managing salinity levels to match the life cycle of shrimp. This ecological condition was later utilised by the Vietnamese government to develop commercial shrimp farming. The narrative of shrimp farming as an adaptation strategy for climate change and saline water intrusion is actually a contingent plan embedded in the existing political-economic structure (Paprocki, 2018, 2019).

Putting these environmental and economic changes in a broader geographical-historical context, however, shows that the transformation of rice and shrimp farming is an economic, political, and infrastructural project that has developed for around 20 years rather than being solely a new climate adaption strategy. In this sense, shrimp farming is just the most recent event in a long history in which the Mekong Delta has become a resource frontier. For instance, after the Vietnam War (1975), Vietnam was isolated by many countries and could not import rice. In the 1980s, the Vietnamese government propagated a "Rice First" policy aimed at ensuring domestic food security (Nguyen et al., 2020). This policy involved the construction of embankments along the Mekong River and coastline to increase farmland and the conversion of saline regions into farmland through the building of perennial irrigation and drainage systems (Perlez, 2016). As a result, the Mekong Delta was transformed from a 'river-water' society into a 'hydraulic society' in an effort to fulfil domestic demands for rice (Evers and Benedikter, 2009; Reis, 2012). After *đổi mới* (economic reforms) in 1986, export-oriented aquaculture, such as catfish and shrimp farming, appeared in the coastal areas of the Mekong Delta. The geographical expansion of shrimp economies in this frontier space is reshaping the biophysical characteristics of shrimp and remaking delta ecologies. In short, commercial shrimp farming is significantly shaping agrarian, economic, and environmental changes in the delta.

In the following sections, I will explain the overarching concepts and contextual detail of this dissertation. Section 1.1 introduces research objectives, theoretical concepts, and research questions. Section 1.2 details the context of the shrimp industry in the Mekong Delta, where the research questions will be examined, to bring together the hatchery, the shrimp farm, and the lab. In so doing, I explain (1) the life cycle of shrimp, (2) the role of water, and (3) the context of the Mekong Delta. Section 1.3 then outlines the structure of this thesis and the main conceptual arguments and empirical details of each chapter.

1.1 Research objectives, concepts, and questions

This section outlines the dissertation’s research objectives and research questions, which centre on the formation, operation, and influence of shrimp economies across the hatchery, the Mekong Delta, and the laboratory. This research argues that water quality, quantity, and ecology play a crucial role in bridging shrimp lives and social lives across different sites in shrimp economies. This research follows the commodity chain of the shrimp industry and divides the shrimp industry into three phases: the reproducing phase in the hatchery, the growing phase on the shrimp farm, and the research phase in the laboratory.

1.1.1 Research objectives

This research has three overarching objectives. The first objective is to analyse the formation and operation of shrimp economies. Shrimp economies are formed and operated by constructing, and then maintaining water-shrimp-human-environment across multiple sites, supported by capitalist and more-than-capitalist relations. The second objective is to develop the concept of hydro-social life to understand the complex relations among water-shrimp-human-environment in the hatchery, the delta, and the laboratory. Humans need to arrange their own lives, such as how they organise their labour, in order to arrange the material conditions shrimp need for processes of (re)production. Humans care for shrimp and their living environment to maintain forms of hydro-social life that sustain commercial shrimp production. The third objective is to investigate the social and geographical differentiation of agrarian, technical, and environmental change in four kinds of shrimp farming. Shrimp economies in Vietnam are composed of four kinds of shrimp farming. Each kind of shrimp farming poses particular challenges for various social groups, technology, the scale of capital, and governmental regulation in different parts of the delta.

This research analyses the formation, operation, and influences of shrimp economies in the hatchery, the delta, and the laboratory within and beyond the Mekong Delta. I argue that shrimp economies, as a form of bioeconomy, require particular sorts of hydro-social life to underpin their operation. To analyse hydro-social life is to examine water-shrimp-human-environment relations that constitute shrimp economies. Each component of these relations can be multiplied and differentiated into various elements (Table 1). For example, whiteleg shrimp and black tiger shrimp propagate larvae in water with higher salinity in the hatchery, while they are bred by farmers in water with lower salinity on shrimp farms. The research investigates these details in the field in order to capture the human and material character and frailties of shrimp economies.

Table 1 The multiplicity of water-shrimp-human-environment relations examined in this thesis

Water	**Shrimp**	**Human**	**Environment**
seawater	*Kuruma shrimp*	*farmers*	*hatcheries*
saline water	*whiteleg shrimp*	*companies*	*laboratories*
freshwater	*black tiger shrimp*	*governments*	*shrimp farms in the Mekong Delta*
wastewater	*giant freshwater shrimp*	*an international NGO*	
virus and bacteria	*brine shrimp*		

Source: Author

1.1.2 Research concepts for shrimp economies and hydro-social life

Shrimp aquaculture is a form of bioeconomy that produces biomass and converts it into value-added products (cf. Ronzon et al., 2015). Although bioeconomy does not have a singular definition in policy and scholarly circles, Birch (2018: 69-70) suggests that bioeconomy should be understood as a master narrative for sustainable development, and we should examine processes underpinning bioeconomy and its outcomes.[1] Many political ecologists have analysed how shrimp farming influences farmers' livelihoods and causes environmental degradation on shrimp farms and the surrounding environment (Goss et al., 2001; Huang, 2015; Marks, 2010; Paprocki, 2018, 2019, 2020; Stonich and Vandergeest, 2001; Vandergeest et al., 1999). Stonich and Vandergeest (2001) have conceptualised these economies in terms of 'crustacean capitalism' to connect commercial shrimp farming to environmental and social relations. However, the shrimp farm is only one of production sites in shrimp economies, as the formation of the aquaculture industry is based on the domestication and heterogeneous gathering of human and nonhuman entities across a range of sites (Lien, 2015: 5). Thus, we need to extend our inquiry to other production sites, such as the hatchery and the laboratory, to understand the formation of shrimp economies. Like salmon aquaculture, the shrimp hatchery is a scientific research site for shrimp domestication and mass production. It is vital to analyse shrimp domestication and reproduction in the hatchery to explore the birth of shrimp aquaculture. In addition, the laboratory plays a crucial role in disease prevention and commodity innovation. Political ecologists argue that marine aquaculture mobilises biotechnology, such as genetic engineering and genetic modification, to prevent diseases and shorten production time (Banoub et al., 2020); but they have not studied how experiments are practised in the lab and biotechnology is applied in the field. This research defines shrimp aquaculture as a kind of bioeconomy and argues that political ecology should extend its focus beyond shrimp farms and into other production sites to recognise the multiplicity of hydro-social life through which

[1] Bugge et al. (2016) generalise three visions in the bioeconomy literature: bio-technology vision, bio-resource vision, and bio-ecology vision. The bio-technology vision focuses on the application and commercialisation of biotechnology. The bio-resource vision emphasises how scientific research is applied in raw material sectors, like agriculture, fishery, and bioenergy, to upgrade the industry. The bio-ecology vision is interested in ecological processes in relation to production conditions, such as the optimum use of resources and environmental degradation.

shrimp economies are constituted.

Aquaculture is a water-based industry. The quantity, quality, and ecology of water constitute ecological conditions of shrimp production. At the recent *POLLEN20: Contested Natures Conference*, Lien (2020) recognised that water was not foregrounded in her ethnography, *Becoming salmon*, and argued that water is a new frontier of capital expansion in marine salmon aquaculture. Instead of viewing water as a frontier, however, this research argues that water is the ecological condition of production that requires meticulous water management for shrimp aquaculture. Water research, particularly urban political ecology, has developed ideas of hydro-sociality to analyse social-nature relations in the circulation of water (Gandy, 2003, 2014; Swyngedouw, 2004, 2015; Kaika, 2005; Linton, 2010; Linton and Budds, 2014; Boelens et al., 2016; Krause, 2018). Drawing on hydro-sociality in water research, this research proposes the concept of hydro-social life to focus on the intersection of the water cycle and aquatic bioeconomies. Breeding aquatic animals needs to manage water-shrimp-human-environment relations for capital accumulation. As in poultry, livestock industries, and animal research, there are farmers, workers, scientists, and technicians who care for farm and research animals and their living environments (Blanchette, 2020; Druglitrø, 2018; Greenhough and Roe, 2019; Lien and Pálsson, 2021; Mol et al., 2010; Porter, 2019). While breeding animals, the cycle of biological life forms and the rhythm of social forms of life are usually aligned to maintain human-animal relationships. Yet, it is worth noting that human-animal relationships are articulated in different historical and geographical sites. Adopting the lens of hydro-social life, this research traces the life cycle of shrimp from hatcheries to shrimp farms and laboratories. Each site of production step operates according to a distinctive logic— such as reproduction, growing, and experimenting —that supports shrimp economies.

This research examines shrimp farms via the notion of hydro-social life to explore agrarian, technical, and environmental changes in the deltaic environment. Marks (2010), an American geographer, conducted his doctoral research project on shrimp farming in the Mekong Delta. He analysed the relations among resilience, land-use change, and social capital in the shrimp industry from institutional economic geography. Although this research also conducts fieldwork in the same area, it develops a different lens to examine agrarian, technical, and environmental changes 10 years after Mark's work. It extends political ecology research, which has largely focused on either terrestrial or marine environments, by foregrounding the amphibious deltaic environment. The emerging area of delta studies proposes that researchers need to analyse how people organise their lives (with other species) around water (Jensen, 2017; Krause, 2017; Krause and Harris, 2021; Morita, 2017; Morita and Jensen, 2017; Morita and Suzuki, 2019). It draws on hydro-social insights to analyse social-nature relations but emphasises the wetness, rhythms, and volatility of the delta. The quantity, quality, and ecology of water are affected by the delta, which would influence ecological conditions of production for shrimp farming. Further, the delta is shaped by devices and infrastructure to maintain water-shrimp-human-environment relations and to reduce uncertainties for shrimp production. Thus, deltas provide the ecological conditions of production for shrimp but at the same time, have a materiality which impedes shrimp production. In short, this research brings together water research, political economy, political ecology, STS, and delta studies.

1.1.3 Research questions, objects, and three phases of shrimp aquaculture

This research addresses three central research questions

1. How are shrimp economies formed and constructed by capitalist and more-than-capitalist relations?

2. What forms do relations among water, shrimp, and humans take shape across different sites of shrimp production: the hatchery, the shrimp farm, and the laboratory?
3. How do shrimp economies affect agrarian, technical, and environmental changes on different types of farmers and capitalists in the four kinds of shrimp farming?

I operationalise these research questions by following the commodity chain of shrimp, particularly whiteleg shrimp, black tiger shrimp, and giant freshwater shrimp, and the supporting industries for shrimp production within and beyond the Mekong Delta. This research divides the commodity chain of shrimp aquaculture into three phases: the reproducing phase in the hatchery, the growing phase in the Mekong Delta, and the research phase in the laboratory. Each site organises a distinctive form of hydro-social life with different goals and functions to assemble the shrimp industry (Table 2). This research designed multi-sited and long-term fieldwork to capture these dynamics.

In the reproducing phase, shrimp are broodstocks in the hatchery, where they are used to reproduce more larvae. The hatchery nurtures broodstocks and reproduces larvae in water of higher salinity. I analyse shrimp reproduction in five hatcheries (two governmental hatcheries and three private hatcheries), which produce the larvae of whiteleg shrimp, black tiger shrimp, and giant freshwater shrimp in Ninh Thuận (Central Vietnam) and the Mekong Delta.

In the growing phase, shrimp are animals on the shrimp farm in the Mekong Delta. The shrimp farm, as a growing site, focuses on feeding shrimp to marketable sizes in

Table 2 Three phases of shrimp aquaculture

Phase	Reproducing Phase	Growing Phase	Research Phase
Shrimp	Broodstocks and larvae	Farm animals	Research animals
Water	High salinity to low salinity	Low salinity	Low salinity
Environment	● Hatcheries are a highly controlled environment	● Integrated mangrove-shrimp farming ● Improved extensive shrimp farming ● Intensive shrimp farming ● Super-intensive shrimp farming	● Labs are a highly controlled environment
Humans	● Family hatcheries ● Foreign companies ● Brine shrimp farmers ● Shrimp feed companies and their local sales agents	● Farmers ● Urban elites ● Foreign companies ● Local governments with different sectors) ● An international NGO	● Farmers ● Scientists ● Technicians ● Governmental research institute
Logics	● The logic of reproduction ● Capitalist technoculture	● The logic of production ● More tensions between capitalist and more-than-capitalist relations	● Scientific research ● Capitalist technoculture

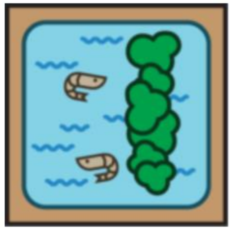
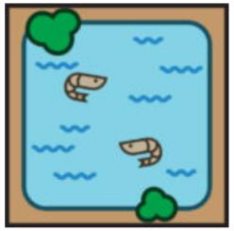
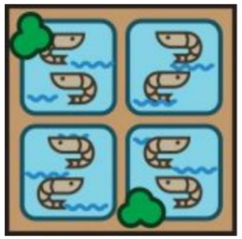
Source: Author

water of lower salinity, but is still confined by rhythms of the delta. This research focuses on four types of shrimp farming – integrated mangrove-shrimp farming, improved extensive farming (rice-shrimp farming), intensive shrimp and super-intensive farming (Table 3) – in Cà Mau, Bạc Liêu, Sóc Trăng, and Bến Tre provinces in the context of ongoing climate change adaption projects from 2019 (Figure 1). These four categories are based on the farming practice, stock density, and the arrangement of shrimp ponds.[2] These categories are often mentioned by governmental research institutes, seafood business investors, and a Vietnamese aquaculture magazine (Tạp chí Thủy Sản) (Seafood Trade, 2019). The four provinces provide a rich account of these four kinds of shrimp farming. In 2017, Cà Mau, Bạc Liêu, and Sóc Trăng were the main shrimp production areas, producing 66% of the total shrimp production in the Mekong Delta (General Statistics Office of Vietnam, 2017). Although Bến Tre does not produce shrimp as much as the other three provinces, it is a huge breeding site for a Taiwanese company, which is a key informant in this research.

In the research phase, shrimp become research animals in the laboratory for scientific research to improve biosecurity practices, develop better shrimp feed, and innovate specific-pathogen-free shrimp. This research visited five public and private laboratories in the Mekong Delta and Hồ Chí Minh City. These labs utilise scientific knowledge to spot potential risks and causal relations between disease and shrimp health as they design marketable products, such as broodstocks, shrimp feed, and probiotics.

[2] There are other ways to categorise shrimp farming models in Vietnam, such as distinguishing intensive and super-intensive shrimp farming by their breeding stages. However, these categories do not fully capture the complexity of shrimp farming in the Mekong Delta.

Table 3 Production systems for shrimp in Vietnam

Graph	**Production System**	**Content**
	Integrated mangrove-shrimp farming	Species: black tiger shrimp (*P. Monodon*) Density: 1-6 black tiger shrimps / m^2 Days: 120-more days for black tiger shrimp Integrated mangrove-shrimp farming is mostly practised in the coastal forests in Cà Mau province, where farmers are restricted from removing mangroves by law. The estimated area of this model is around 50,000 hectares. Due to low stock density, integrated mangrove-shrimp farming accounts for a small percentage of the total shrimp production in Vietnam.
	Improved extensive shrimp farming (rice-shrimp farming)	Species: black tiger shrimp (*P. Monodon*) and giant freshwater shrimp (*M. rosenbergii*) Density: 4-6 black tiger shrimps / m^2 or 2-6 giant freshwater shrimps / m^2 Days: 120- more days for black tiger shrimp or 60-90 days for giant freshwater shrimp In this model, farmers usually breed black tiger shrimp in the dry season and grow rice and giant freshwater shrimp in the rainy season. Because of the low output, this model accounts for 13% of the total shrimp production.
	Intensive shrimp farming	Species: black tiger shrimp (*P. Monodon*) or whiteleg shrimp (*L. Vannamei*) Density: 35-40 black tiger shrimps / m^2 or 90 whiteleg shrimps / m^2 Days: 110-140 days for black tiger shrimp or 90-100 days for whiteleg shrimp Intensive shrimp farming is the dominant practice in coastal areas, such as Sóc Trăng and Bạc Liêu province. With a total farming area estimated at 61,000 hectares in 2014, it approximately contributed 80% of the overall production in Vietnam.

	Super-intensive shrimp farming	Species: whiteleg shrimp (*L. Vannamei*) Density: 200-500 shrimps / m^2 Days: 85-105 days Since 2011, super-intensive shrimp farming has been deployed in the Mekong Delta, such as Cà Mau, Bạc Liêu, and Bến Tre provinces. The most famous example is the farm factory operated by Việt Úc company, a well-known Vietnamese and Australian joint company.

Source: (Seafood Trade, 2019)

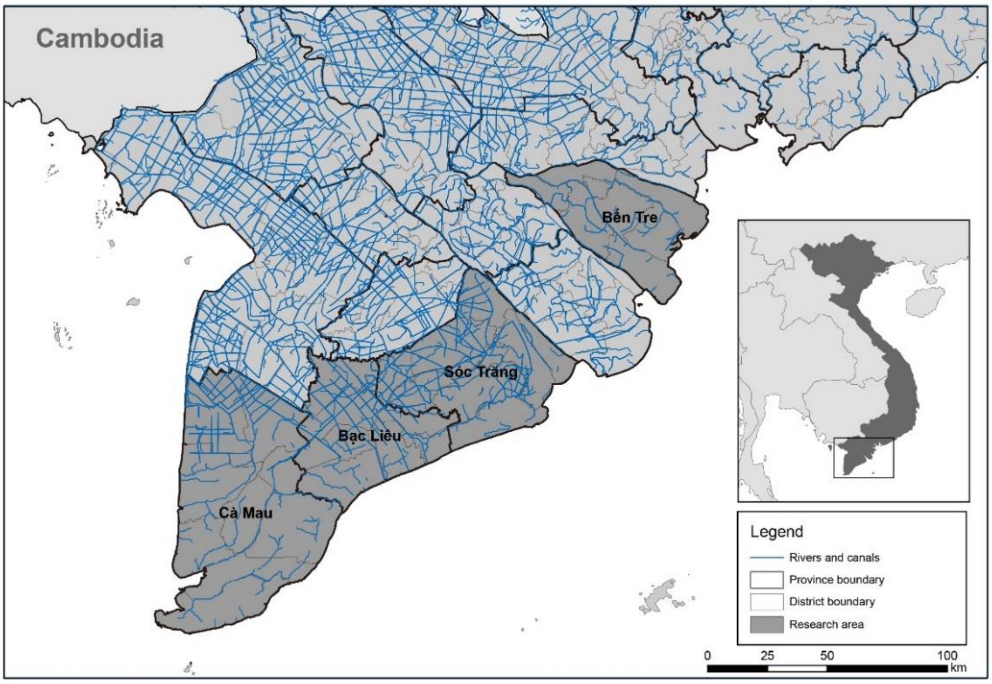


Figure 1 Research sites in the Mekong Delta

Source: Author

1.2 Shrimp economies in the Mekong Delta

This section introduces the empirical context in which I examine my research questions. First, it explains the life cycle of shrimp to show how the shrimp industry is divided into the reproducing phase in the hatchery, the growing phase on the shrimp farm, and the research phase in the lab. Second, it focuses on how water quality influences the growth of shrimp and the risk of shrimp disease. Third, this section outlines the brief history of water management and land-use planning in the Mekong Region.

1.2.1 The life cycle of shrimp

Understanding shrimp domestication enables us to know how the shrimp industry operates in different phases for shrimp reproduction, growth, and scientific research. In the wild, most kinds of shrimp, such as black tiger shrimp and whiteleg shrimp, are catadromous: shrimp lay eggs and hatch in the estuary or the ocean where salinity is around 28-30‰, and subsequently grow up in a less saline environment (Figure 2). In the early growth stage, from fertilised eggs to mysis, larvae live offshore where water has higher salinity (around 30‰) and transform rapidly. It takes 24 hours for nauplii to come out from the egg, and 24-48 hours to grow from nauplii to zoeae. After 3-5 days, zoeae become mysis. In the last 3-5 days of the mysis stage, mysis move to the estuary or rivers of lower salinity and gradually grow into postlarvae.

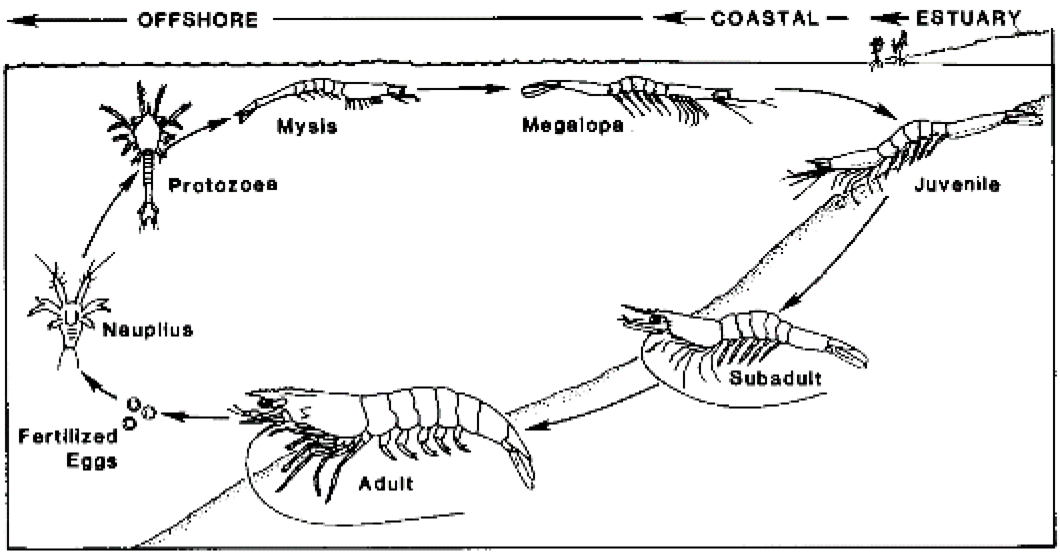


Figure 2 The life cycle of a typical penaeid species with stages in different habitats
Source: (Bailey-Brock and Moss, 1992)

Aquaculture domesticates shrimp by unpacking the life cycle of shrimp, mimicking their living environments, and reproducing and growing them on a commercial scale. To achieve these goals, shrimp aquaculture spatially and temporally reassembles the life cycle of shrimp and their living environments. The life cycle of shrimp is divided into two phases: the reproducing phase in the hatchery and the growing phase on the shrimp farm (Figure 3).

In the reproducing phase, the hatchery aims to nurture broodstocks and reproduce larvae in water of higher salinity. The hatchery collects wild bookstocks or imports bookstocks from other places, such as Hawaii and Thailand. Broodstocks are stored and nurtured in maturation tanks with higher water salinity (around 30-35‰). After one month, companies move broodstocks into spawning tanks and create a mating atmosphere for them to spawn eggs. After that, companies collect eggs to hatch nauplii in larval rearing tanks. After 26-31 days, nauplii grow up as postlarvae, and companies sell them to farmers.

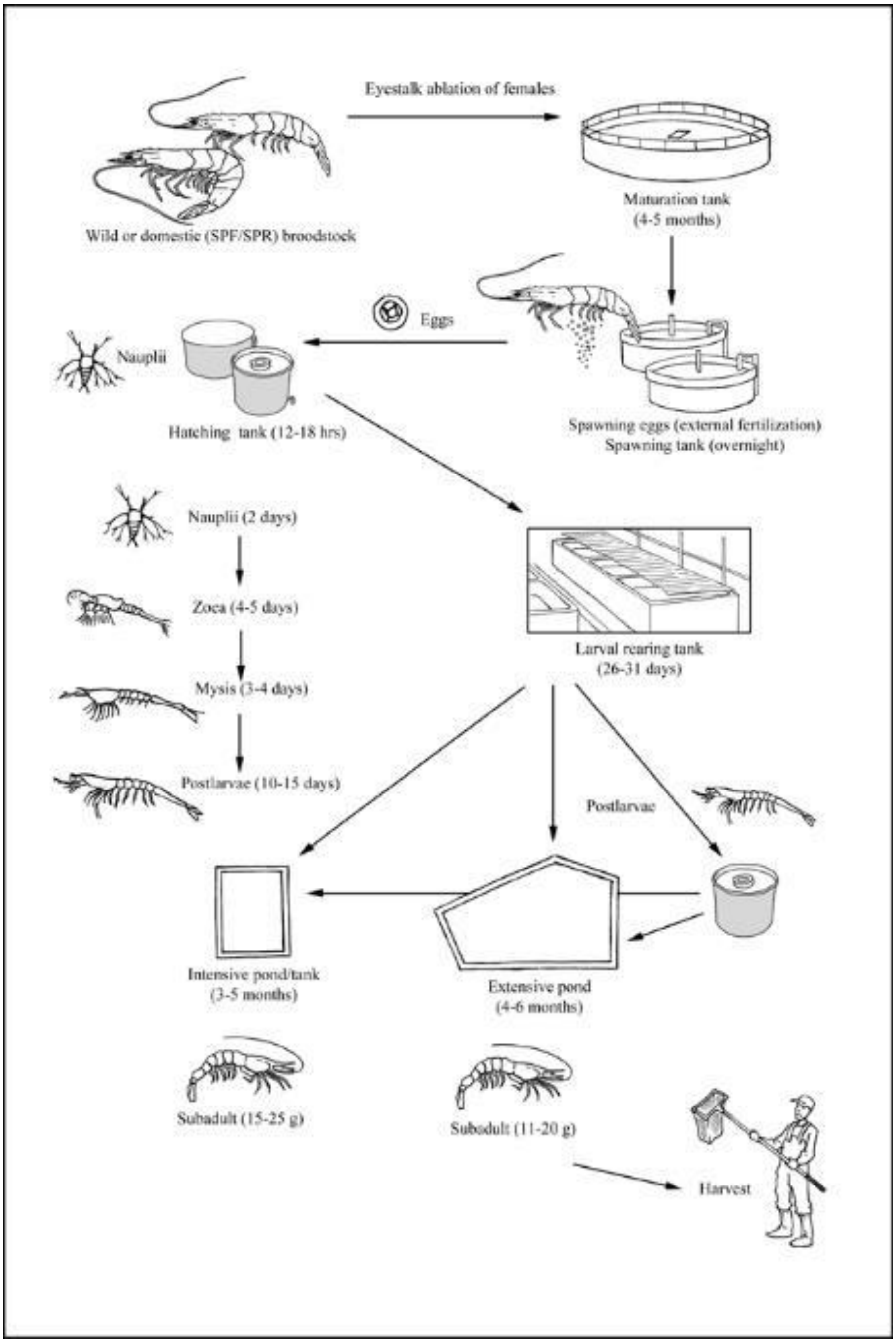


Figure 3 The production cycle of whiteleg shrimp (*Penaeus vannamei*)
Source: (Food and Agriculture Organization of the United Nations, 2019a)

In the growing phase, the shrimp farm as a growing site focuses on feeding shrimp to bigger sizes with lower water salinity. Farmers buy postlarvae from the hatchery and breed them in brackish water in the shrimp pond. In this stage, farmers and companies aim to grow shrimp into marketable sizes. To achieve this goal, farmers and companies in different places and countries can adjust water salinity, stock density, breeding and harvesting timing, and the design of shrimp ponds. In the Mekong Delta, farmers usually keep water salinity at around 14‰, which takes 90-100 days for whiteleg shrimp and 110-140 days for black tiger shrimp to grow to marketable sizes.

In addition, the research phase plays a crucial role in developing the shrimp industry. When thousands of shrimps are confined in a pond, this mode of industrial production causes immense pressure on shrimp and creates unforeseen changes in the microbial environment. The industrial mode of production has a higher risk of shrimp disease. As a result, biosecurity practices are taken to manage water-shrimp-human-environment relations to avoid the economic loss or even market crisis in the hatchery, on the shrimp farm, or in the lab. Shrimps are delivered from the hatchery and the shrimp farm to the laboratory for testing and experiments. Tests and experiments help farmers and companies to know water quality, the health status of shrimp, and the development of new shrimp feed and specific-pathogen-free shrimp.

1.2.2 Water matters

Shrimp are aquatic animals and live in water. Breeding shrimp requires managing water quantity, quality, and ecology to match the life cycle of shrimp and to reduce the risk of shrimp disease.

Water quality and the life cycle of shrimp need to be aligned. Shrimp are euryhaline animals, which can survive in a wide range of salinity. Black tiger shrimp and whiteleg shrimp can survive in water salinity of 4-35‰ and 1-40 ‰ respectively.

In the reproducing phase, the hatchery requires seawater (salinity around 30‰) to fill tanks for nurturing broodstocks and propagating larvae. After propagating larvae for around 30 days, the hatchery decreases water salinity from 30‰ to 14‰ and packs larvae in plastic bags for delivery to shrimp farms and labs. In the growing phase and the research phase, the shrimp farm and the lab require saline water (salinity around 14‰) to fill tanks and shrimp ponds for breeding shrimp and conducting experiments. It is worth noting that farmers adjust their breeding strategies to the interconnection between the flexibilities of shrimp and ecological conditions of shrimp production (cf. Bustos-Gallardo et al., 2021). Farmers can grow shrimp in water with a salinity in the range of 4-35‰. Water salinity influences the growth rate of the shrimp: shrimp grow faster in water of lower salinity and slower in water of higher salinity. Slow growth shrimp usually have denser meat, a higher price but a more extended period of investment, which could be a risk for farmers since the risk of disease infection is higher.

Water also contains other life forms, such as algae, plankton, bacteria, and viruses, which constitute water ecology. Throughout the whole life cycle of shrimp, aquaculture must maintain the water ecology to keep shrimp healthy. Water ecology shapes the health status of shrimp and could make shrimp ill under environmental pressure, such as drastic temperature changes and a huge amount of ammonia, virus, or anaerobic bacteria. If the hatchery, the shrimp farm, and the lab have enough capital and water, they can construct an improved water system, which sterilises and exchanges water daily, to maintain the water ecology. Thus, water quality and water ecology are related to water quantity.

1.2.3 Settling in the Mekong Delta

Shrimp farming is widely practised in South, Southeast Asian, and Central American countries. Each country has different water and land issues with shrimp aquaculture.

The transformation from rice to shrimp in the Mekong Delta should be understood from a broader geographical and historical context that ranges from colonial history, via the Cold War, to the current climate adaptation strategy. In the following, I will examine water management and land-use planning in the Mekong Region on a regional and national scale. On the regional scale, water management in the Mekong Delta is deeply affected by hydropower dams upstream. The construction of hydropower dams has been a geopolitical issue from the Cold War till now. On the national scale, the shift from rice to shrimp farming is influenced by state policies. The state policies for domestic food security and export-oriented aquaculture are underpinned by infrastructure construction from the colonial period.

On the regional scale, dam construction in the Mekong Region has been highly influenced by geopolitics within and beyond Southeast Asia. In the late 1950s and early 1960s, US foreign policies in Southeast Asia aimed to achieve the geopolitical goals of the US, defending against the spread of Communism and promoting developmental goals of Southeast Asian states in the lower Mekong basin through large-scale water resource development (Sneddon, 2012). In this geopolitical context, experts exported their philosophy of water management together with economic and political liberalism (Schmidt, 2017). Gilbert White, an influential geographer in American water management and international water policy, was on the Mekong Committee and proposed integrated water management as a means to secure regional peace in the Mekong (Schmidt, 2017: 125). White (1963) proposed that, while applying multi-purpose development in the Lower Mekong, planners and decision-makers needed to review other similar experiences and their social consequences worldwide.

After the Cold War, the regional geopolitical imagination of the Mekong Basin had transformed from a front line to a corridor of commerce, where China, Lao PDR, and Cambodia have the greatest hydropower potential (Bakker, 1999). However, hydropower development induced a new form of regional conflict. For example, the Laos government and Thai private investors co-developed hydropower dams and controlled benefits but impacted the environment and vulnerable downstream farmers (Matthews, 2012). Currently, sustainable hydropower in the Mekong region is proposed as a new way for keeping economic growth and incorporating environmental protection, but sustainable hydropower still has many uncertainties in knowledge production and infrastructure construction (Whitington, 2019). Due to the upstream dams, farmers in the Mekong Delta do not have enough freshwater from rivers and have to wait for rainfall to desalinise their farmland.

On the national scale, land use in the Mekong Delta shifting from agriculture to aquaculture is related to state policies, infrastructure development, and climate change adaptation. Since the French colonial period, French, American, and Vietnamese engineers have reclaimed land and drained the water off to increase arable land in the Mekong Delta. After the Vietnam War and the reunification in 1975, Vietnam was internationally isolated. Thus, the Vietnamese government increased rice production in the Mekong Delta for domestic food security. The Mekong Delta has become Vietnam's main rice production area (a rice bowl). In 1986, the Vietnamese government launched *đổi mới* (economic reforms) to encourage free-market development with socialist characteristics. In 2000, the Vietnamese government released the land-use policy liberalisation under Decision NQ/CP-09 to allow farmers to shift the farming system regionally. Although the land is owned by the state, farmers have land tenure for 50 years and can transfer the ownership to others. For farmers, the collapse of collectivisation and the commodification of land promised them better living conditions: farmers wanted to farm their own land (Kerkvliet, 2006). Shrimp farming in the

Mekong Delta is not a subsistence economy but is export-oriented (Scott, 1977; McElwee, 2007). Export-oriented shrimp aquaculture reinforces capital relations and makes farmers highly embedded in the global market. The high demand and the higher price of shrimp in the global market also pushed farmers toward converting their lands into shrimp ponds.

The Vietnamese government both regulates and facilitates the development of shrimp farming across the Mekong Delta (Nguyen et al., 2020). Since 2011, Dutch experts and government have exported their engineering and water management to Vietnam and other countries (Hasan et al., 2019). Vietnamese and Netherland experts cooperatively developed the Mekong Delta Plan, which aims to develop the potential productivity of the delta, to alleviate vulnerability to risk, and to integrate water resources management and land use planning under a wide range of socio-economic scenarios (The Socialist Republic of Vietnam, 2013). The Mekong Delta Plan depicts the similarity of the flood-prone delta between the Netherlands and Vietnam, and proposes the Netherlands' experience as a role model for Vietnam. This plan reflects what Schmidt (2014) terms 'the procedural turn' in water management, where the goal is to create effective deliberative decision-making institutions. This plan is executed by a consortium composed of several research institutions, consultant companies, government sectors, and NGOs from both Vietnam and the Netherlands. The report shows the short-term and long-term strategies in different parts of the Mekong Delta, making institutional norms fit with social-ecological systems. For example, introducing double rice and flood-based aquaculture to upstream areas to replace triple rice cropping and integrated mangrove-shrimp farming to the coastal area.

1.2.4 Caveats

It is worth noting that shrimp farming does not fully replace shrimp fisheries. According to the Food and Agriculture Organization of the United Nations (FAO), production from both capture fisheries and aquaculture in Vietnam steadily increased from 1980 to 2017 (Figure 4). First, many shrimp species are still not domesticated and are mainly caught by fishing, such as mantis shrimp and sergestidas shrimp. Second, the relationship between the shrimp fishery and shrimp farming is not a linear progression from the former to the latter. For example, Kuruma shrimps were domesticated and once bred in ponds but are now mainly caught from the ocean due to their specific requirement for a sand bed in ponds and the outbreak of shrimp disease. Third, the shrimp fishery is a complementary source of broodstock families for shrimp aquaculture. Even though certain kinds of shrimp are domesticated, international breeding companies or hatcheries still catch wild mature shrimp from the sea or buy them from people who fish. These companies breed wild mature shrimp as broodstocks to build up their broodstock family and to enrich the genetic diversity of their broodstocks. For example, a bottleneck in domesticating blue shrimp is that companies do not have enough genetic diversity in their broodstock families. Fourth, the shrimp fishery and shrimp aquaculture sometimes are in a competitive relationship. For example, Marks (2015) compares production conditions in the Louisiana shrimp fishery and the Mekong Delta shrimp industry. He argues that globalisation deepened the cost/price crisis of the 2000s and raised conflicts between Louisiana and Mekong Delta shrimp producers.

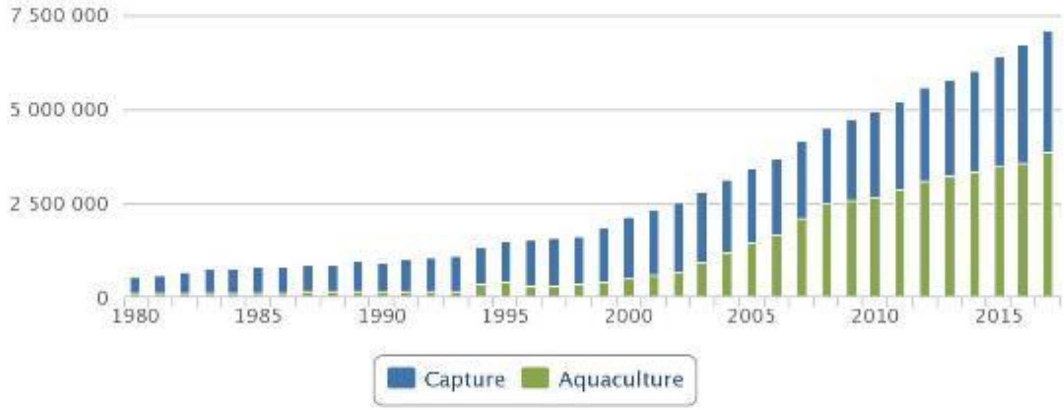


Figure 4 Capture and aquaculture production in Vietnam (tonnes)
Source: (Food and Agriculture Organization of the United Nations, 2019b)

1.3 Thesis structure

This thesis has six other chapters. In Chapter 2, I develop the notion of hydro-social life that underpins shrimp economies by reviewing relevant work in water research, political economy, political ecology, science and technology studies, and delta studies. First, I draw on water research to develop the notion of hydro-social life. Hydro-social life is composed of biological life forms and social forms of life, which support the formation and operation of shrimp economies. Second, this chapter unpacks shrimp economies from two aspects: their (1) materiality and (2) capitalist and more-than-capitalist relations. Third, this chapter contextualises shrimp economies and hydro-social lives in the hatchery, the delta, and the laboratory. These three kinds of sites are contact zones within which water-shrimp-human-environment relations are reconfigured across the different phases in shrimp economies.

Chapter 3 outlines the research design and methodology for tracking shrimp aquaculture across the hatchery, the laboratory and the Mekong Delta. In terms of research design, this research adopts multi-species and multi-sited ethnography to track the commodity chain of shrimp aquaculture across the hatchery, the Mekong Delta, and the laboratory. Each site requires a tailored research method: delta methods, laboratory ethnography, and the combination of these two methods for the hatchery. As for the methodology, this research gathers multiple forms of data relevant to shrimp economies by participatory observation, semi-structured interviews, and secondary data analysis. It also considers and follows the ethical principles for social science research. In the last section, I elaborate processes and challenges of conducting fieldwork in the context of authoritarianism.

Chapter 4 explores the reproducing phase of shrimp aquaculture in the hatchery. It reviews the history of shrimp domestication in Japan, Taiwan, and the United States to depict the birth of hatchery and shrimp aquaculture. It argues that shrimp domestication is completed by technological developments and multi-species entanglement in multiple sites. It then examines how shrimp economies were made scalable on a commercial scale in the hatchery. It depicts the processes of shrimp reproduction from buying broodstock, nurturing broodstock, and preparing the living environment and mating atmosphere. Finally, it visits three supporting industries — an algae hatchery, brine shrimp farms, and shrimp feed companies — to explore how other species are associated with shrimp aquaculture. It shows how these species and products also take part in the hydro-social life of shrimp.

Chapter 5 focuses on the growing phase of shrimp farming in the deltaic environment. This chapter contextualises the formation of commercial shrimp farming in the Mekong Delta. It shows how four kinds of commercial shrimp farming in the Mekong Delta take place under different physical conditions and social relations. This research then analyses the multiple forms of hydro-social life at the growing phase. Farmers, workers, and companies construct shrimp ponds with various devices and infrastructure and align their everyday life with the life cycle of shrimp. The land-water interface in the delta facilitates (and sometimes impedes) the operation of shrimp economies. Meanwhile, the operation of shrimp economies is supported by capitalist and more-than-capitalist relations. Finally, this chapter analyses the moment shrimp become a commodity when they are detached from the delta and attached to transaction prices. Harvesting shrimp is a part of hydro-social life because it depends on the social, biophysical, and planetary rhythms in the delta.

Chapter 6 investigates the research phase of shrimp economies in the laboratory. Hydro-social life is again reassembled, this time for the lab. First, labs provide testing services to know water ecologies and the health status of shrimp. The testing result helps farmers and companies to adjust pond management and make economic decisions. Second, this chapter analyses how labs develop biosecurity strategies with an anticipatory logic by modifying the body of shrimp and incubating probiotics for pond water and shrimp intestines. These biosecurity strategies are later deployed from the lab to the farm to reshape water-pathogen-shrimp-human-environment relations. Third, this research unpacks how labs create a distinctive hydro-social life to produce scientific knowledge by conducting shrimp experiments, such as shrimp feed trials, disease challenges, and blood testing. Scientists and technicians not only feed and care for shrimp but also poison and kill them, which trigger concerns regarding animal ethics.

Chapter 7 draws together the key arguments to highlight the contributions of this dissertation and to suggest potential directions for future research. There are three key theoretical contributions. First, this research critically extends work in political economy and political ecology on the socio-natural organisation of commodity production. It does this by analysing the commodity chain of shrimp production across three sites— the hatchery, the laboratory, and the delta — to constitute commercial shrimp farming in Vietnam. Second, this research contributes to water research by bringing together social lives and shrimp lives via the concept of hydro-social life. The multiple ontologies of water are integral to shrimp production. Third, this thesis contributes to delta studies and science and technology studies by unfolding hydro-social life across three sites. The dissertation's focus on understanding water ecologies within and beyond the delta, in different seasons and under conditions of climate change, provides a rich, empricially-grounded account of the interaction between commodity production and environmental change.

Chapter 2 Shrimp Economies and Hydro-social Life

In this chapter, I review the literature to outline the key theories and concepts underpinning this dissertation. I introduce the notion of hydro-social life, review the concept of shrimp economies, and contextualise these two concepts via the three spaces of the hatchery, delta, and laboratory. In section 2.1, I propose and develop the idea of hydro-social life as a way to express how water is entangled with biological, economic, and social processes. It analyses how water straddles biological life forms and social forms of life. The notion of hydro-social life enables us to understand how shrimp economies are produced through entangled water-shrimp-human-environment relations. Section 2.2 places hydro-social life in the context of political economy and political ecology by reviewing the formation and operation of shrimp economies. On the one hand, it examines the material basis that supports shrimp farming, like domestication, industrialisation, and the practices of care that maintain water-shrimp-human-environment relations. On the other hand, it analyses capitalist and more-than-capitalist relations that support shrimp economies and cause agrarian, technical, and environmental changes. In section 2.3, I summarise how the dissertation draws on delta studies and science and technology studies to navigate shrimp economies and hydro-social lives in the hatchery, delta, and laboratory.

2.1 Hydro-social life

The concept of hydro-social life is inspired by the discussion of hydro-sociality in water research. The concept of hydro-sociality has been addressed in water research and political ecology in various terms, such as hydro-social metabolism (Swyngedouw, 2004, 2015; Kaika, 2005), hydro-social cycle (Bakker, 2010; Gandy, 2014; Linton, 2010; Linton and Budds, 2014), hydro-social territory (Boelens et al., 2016), hydro-social citizenship (Gearey et al., 2019), and hydro-social lifeworlds (Krause, 2018a).

These terms aim to answer two fundamental questions: (1) What is water? (2) How does water fit with society (Schmidt, 2014)? In the following, I will answer these two questions by developing the notion of hydro-social life to analyse the entanglement of water and life.

2.1.1 Multiple ontologies of water

In terms of the first question, water researchers recognised that there are many waters with diverse qualities and characteristics in the real world (Hamlin, 2000). Yates et al. (2017) argue that water is an ontological plurality. Water rarely exists as H_2O in high purity without other elements. Water contains H_2O, OH^-, H_3O^+, other ions, nitrogen, viruses, bacteria, and other elements and life forms (Chang, 2014; Helmreich, 2011). Vandewall (2007) argues which properties are essential to explain the material and its behaviours depend, to a significant extent, on the focus of the observer. For instance, shrimp aquaculture requires water with different salinity levels, so sodium chloride is an essential property of water in this context. Furthermore, water is always internally articulated with economic, social, cultural, and political relations, which is a hydro-social process (Linton and Budds, 2014; Swyngedouw, 2004, 2015). Water researchers examined how water is produced and circulated in different historical, social, political, institutional, and technological circumstances, like privatisation (Bakker, 2004, 2010; Gandy, 2003; Swyngedouw, 2004), authoritarianism (Swyngedouw, 2015), postcolonialism (Anand, 2017; Bjorkman, 2015), postapartheid (von Schnitzler, 2016), and water activism (Pauli, 2019). They have shown water is more than a passive object and can be thought of as a nonhuman actant (Linton and Budds, 2014; Swyngedouw, 2015). Bakker (2012) argues that water has many facets, like forms, states, materialities, spatialities, and temporalities, which cause contested relationships over time and space. For instance, water affects human and non-human life by flowing between their bodies and the environment. Water transgresses geopolitical boundaries and causes international conflicts in watershed governance. In short, water is social-natural objects and hydro-social processes.

Hydro-social life focuses on how water is entangled with life forms. The reading of water as a hybrid object in hydro-sociality is influenced by the early work of Bruno Latour and Donna Haraway on the hybrid object and the cyborg manifesto (Haraway, 1991; Latour, 1993). The later works from Donna Haraway on companion species can also contribute to hydro-sociality in the discussion of water and life. Water is an essential element for life. Haraway (2007: 3) argues that 'becoming with' companion species is a practice of becoming worldly. Humans, water, and aquatic animals are not pre-existing subjects or objects but are always entangled to be existing. Humans care for aquatic animals by managing water quantity, quality, and ecology. Meanwhile, the everyday life of humans is shaped by the hydrological cycle and the life cycle of shrimp. Therefore, humans are becoming with water and life forms that are in, and make up, water.

By engaging water's hybrid relations, hydro-social life extends water research to other physical properties of water, such as water quality and water ecology. These expand hydrosocial scholarship to considerations of both social forms of life and multiple life forms. Aquaculture, for instance, is a form of water-based production that does not require a high degree of water purity but rather diverse forms of water quality and water ecology for shrimp. Previous water research overwhelmingly focuses on freshwater, and only some urban political ecologists discuss other kinds of water, such as purifying seawater through desalinisation and sediments in the river (de Micheaux et al., 2018; Williams and Swyngedouw, 2018). Hydro-social life, by contrast, is developed in this dissertation to connect hydro-sociality with delta studies, since shrimp aquaculture is often located at the interface of land and sea and the mixture of salt and freshwater systems, particularly the deltaic environment (cf. Krause, 2018a).

2.1.2 Water meets worlds

In water research and political ecology, scholars often claim that water fits with society through modernity, state rationality, and scientific standardisation (Bakker, 2010, 2012; Gandy, 2003, 2014; Linton, 2010; Swyngedouw, 2015). However, water in real worlds does not always fit with modernity since we talk about and use water without necessarily thinking about theories of modernity, rationality, or science. Schmidt (2017) argues that critical readings of water as tied to modernity often simplify the reduction of water into H_2O or to “natural resources” legible to the state. It is inaccurate, he argues, to have a singular approach that includes all biological life forms and sociological forms of life. In real worlds, water has diverse ontologies and is contingently articulated with diverse societies. To undo the conundrum, Schmidt (2017) suggests that we should focus on the form of life through which particular ways of knowing water take shape. These forms of life include practices and judgements that are developed in relation to others and the environment and are not reducible to a singular narrative. We learn to manage water, he argues, through judgments that fit with our forms of life more broadly (Schmidt, 2017). In so doing, Schmidt analysed liberal forms of life in the American philosophy of water management by historical analysis. This dissertation, by contrast, unites concerns with life forms and the form of life at work in bioeconomies. To do so, it adopts an ethnographic approach to tell stories of water meets worlds.

This research proposes the notion of hydro-social life to analyse how water is entangled with biological, environmental, and social processes in shrimp production. Hydro-social life conceptually glues together biological life forms and social forms of life in bioeconomies. In this research, the notion of ‘life form’ refers to organisms with physical, metabolic, and ecological possibilities; and ‘form of life’ means the social and cultural ways of thinking and acting in more-than-human society (Helmreich, 2009; Helmreich &Roosth, 2015). In aquaculture, the life of aquatic animals is entangled with water, and water management is also determined by various forms of life, such as economic activities, social norms, technical criteria, and cultural practices (Helmreich, 2009; Lien, 2020). Meanwhile, forms of life are themselves shaped by life forms. Breeding animals in different contexts requires reorganising human communities to fit with the life and death cycle of species (Blanchette, 2020: 4). The life and death of shrimp is affected by how humans manage water quality and ecologies for shrimp growth and shrimp experimentation. For instance, aquaculture use genetic engineering and bioinformatic techniques to explore the possibilities of life itself. Meanwhile, using biotechnologies to construct life forms are shaped by forms of life, such as economic, social, and ethical concerns (Blanchette, 2020; Helmreich, 2009; Porter, 2019; Schrepfer and Scranton, 2004). In short, water straddles social forms of life and the conditions for multiple life forms. And, in sum, the concept of hydro-social life points to how understanding shrimp bioeconomies requires understanding the biophysical and social worlds that together make them up.

This research tells stories of water meets worlds with the notion of hydro-social life in the writing of water-shrimp-human-environment relations. This writing gathers key elements and presents their relations in terms of hydro-social life. In this writing, the hyphen is a semiotic marker, reflecting epistemological, ontological, and methodological perspectives. The hyphen can act as a divider or an uniter. For instance, in the discussion of nature-society, Huber (2010) argues that the hyphen-as-divider indicates that nature and society are two independent realms, while the hyphen-as-uniter focuses on mutual relationships between nature and society. The hyphen-as-uniter has an open epistemology to overcome the problem of natural-society dualism within the hyphen-as-divider. However, this research argues that hyphens in water-shrimp-human-environment relations can act as both a divider and uniter to exhibit an open epistemology and multiple ontologies. The hyphen-as-divider breaks down shrimp economies and hydro-social life into the empirical component to define the unit of analysis. As I mentioned in the research objectives (section 1.1.1), each empirical component can be diversified in different contexts, showing multiple ontologies of each component. At the same time, the hyphen-as-uniter glues these components to capture dynamic relations in shrimp economies and hydro-social lives. The different component combination creates multiple relations that are all accounted as a part of shrimp economies and a form of hydro-social life. It is inadequate to only focus on one component without thinking through these broader relations. Bateson (1972: 231) examines the boundary of thoughts by giving a vivid example of a blind man with a walking stick. The self and thought of a blind man reside neither at the tip nor in the handle of the stick but in the relational system of the blind man, the ground, and the stick. Epistemologically, analysing shrimp economies and hydro-social life requires understanding relations among the components. Methodologically, hyphens signal how one might add to water-shrimp-human-environment relations depending on research questions, foci, and sites of inquiry.

This research answers the two fundamental questions for hydro-sociality by developing the notion of hydro-social life. First, it explains how water is entangled with life forms and forms of life in bioeconomies. Second, it tells geographic stories of water-meets-worlds by writing water-shrimp-human-environment relations. This writing practice indicates both components and their relations in ecological conditions of shrimp economies. Hydro-social life needs to be further developed to explore various forms of life, which constructs water-shrimp-human-environment relations, in the context of shrimp economies.

2.2 From crustacean capitalism to shrimp economies

This research nests hydro-social life within the context of shrimp economies. Shrimp economies — like related efforts to situate capitalism's inherent ecologies, such as crustacean capitalism, blue-green capitalism, viral economies, and plantation life (Helmreich, 2009; Li and Semedi, 2021; Porter, 2019; Stonich and Vandergeest, 2001) — examine how life forms and forms of life mutually shape each other, constituting shrimp as an economic object that circulates within the commodity chain (Berndt and Boeckler, 2011). This research uses the notion of crustacean capitalism as a launching point to examine diverse shrimp economies. As a concept, crustacean capitalism sheds light on the material basis of shrimp farming and agrarian changes caused by commercial shrimp farming. Crustacean capitalism was originally defined in reference to how the materiality of shrimp, such as their life cycle, shapes the operation of commercial shrimp production and how commercial shrimp farming creates many tensions and violence to influence the environment and social relations needed to profit from shrimp (Stonich and Vandergeest, 2001).

However, crustacean capitalism as a research framework has two limitations. First, it tends to neglect more-than-capitalist relations that support crustacean capitalism and which, in settings like Vietnam, can have a substantial role, such as unpaid labour, family kinship, gender divisions, and other social relations (Gibson-Graham, 2006). Second, it assumes a linear commodity system in which most barriers to the expansion of capitalist relations are overcome. Yet, in practice, the shrimp industry is characterised by a variety of alternative and nonscalable practices. Tsing (2012) refers to these practices in terms of frictions that impede and facilitate scalable economic projects. To address these issues, this research proposes an approach to shrimp economies that incorporates practices that are external to markets but which are essential to shrimp economies, and addresses the tensions that arise in assumptions regarding linear economies of scale. Overall, then, this project expands the terms of reference for crustacean capitalism to think more broadly about (2.2.1) the materiality of shrimp production, and (2.2.2) capitalist and more-than-capitalist relations that underpin the operation of shrimp economies.

2.2.1 The materiality of shrimp production

Analysing the material basis of political economy and political ecology is crucial to understanding the formation and operation of shrimp economies. First, materiality helps us see how biological processes might impede the flow of capital or create opportunities for capital circulation (Bakker and Bridge, 2006). Second, it acknowledges how social-technical practices shape the form and character of materiality (Bakker and Bridge, 2022). Third, it also recognises the heterogeneity and liveliness of nonhuman entities (species and things) and plural ontological possibilities (Bakker and Bridge, 2022). In the following, this research reviews the discussion of shrimp aquaculture in political economy and political ecology from three aspects: (1) views of nature as obstacle, opportunity, and surprise, (2) social-technical practices of care, and (3) the literature's appreciation of heterogeneity and liveliness of species.

First, political economy and political ecology have argued that nature can be an obstacle, an opportunity, and a source of surprise with the lens of industrial dynamics (Banoub et al., 2020; Boyd et al., 2001). With the development of technology, nature-based industries can overcome natural obstacles and industrialise agriculture and aquaculture production through the strategies of appropriation and substitution. Boyd et al. (2001) proposed the formal subsumption and real subsumption of nature to discern the natural and biophysical processes that can or cannot be industrially substituted. Formal subsumption refers to biophysical processes that firms need to confront and which cannot be intentionally transformed into their process of commodity production. Real subsumption, by contrast, can systematically increase and intensify biological productivity by industrialising organisms. Industrialising organisms entails modifying the body of animals and making them fit for particular physical and social environments (Schrepfer and Scranton, 2004). In aquaculture, biotechnologies such as genetic selection, shrimp feed, and the reproducing technology of larvae aim to accelerate production time, increase yields and improve disease resistance (Banoub et al., 2020). Aquaculture physically constructs the domus (home) of salmon and shrimp as key architectures to enhance productivity by bringing together heterogeneous elements, such as land, water, oxygen pipeline, ventilators, and labour (Lien, 2015).

Political ecologists argue that it is crucial to see how scalable and nonscalable ecological and economic relations work in places (Tsing, 2015: 42). Aquaculture mobilises various material elements and natural environments to make shrimp economies scalable (cf. Hall, 2003; Huang, 2015; Saguin, 2016; Stonich and Vandergeest, 2001). Stonich and Vandergeest (2001) generalise that the biological characteristics of shrimp shape social processes. For instance, the size of containment and the stock intensity of shrimp are related to the availability of land, credit, and labour. The size of containers depends on capital investment and access to land. The higher stock intensity of shrimp requires more input of shrimp feed, which is the main expense of shrimp farming. Similarly, the different sizes of shrimp determine their price. For Stonich and Vandergeest, the equations of shrimp economies are straightforward: lands, ponds, and equipment are the means of production, shrimp are a commodity, and nature presents both resources and obstacles in shrimp economies. However, making nature-based industry scalable as a factory model is complicated by social and ecological complexity. Like sugarcane plantations of the New World in the eighteenth century or oil palm plantations in contemporary Indonesia (Li and Semedi, 2021; Moore, 2015), shrimp aquaculture tends to unfold as a process of modular simplification in which amphibious ecologies are simplified into a monoculture. The resulting, homogenised ecologies and environments become a hotbed for shrimp disease and create ecological externalities, such as polluted water and soil for adjacent regions (Stonich and Vandergeest, 2001). It also creates conditions for the proliferation of feral forms that threaten biosecurity (Tsing et al., 2019).

Marxian approaches propose the notion of commodity frontier to examine how the periphery is constantly unmade and remade into the edge of time and space for resource extraction and capital accumulation by material, economic, discursive, and political elements (Cons and Eilenberg, 2019; Tsing, 2004). This also deeply shapes local ecologies and livelihoods. The commodity frontier is imagined as an untouched space but is actually produced through the previous resource governance and economic practices. For example, the commodity frontier often maps out the area of resource extraction and excludes the relationship of residents and Indigenous people to land (see McElwee, 2016). However, the operation of commodity frontier usually involves local communities as well, such as hiring indigenous workers (Montagnard workers) to manage rubber forests in Vietnam (Aso, 2018). Tsing (2015: 132) suggests that we should listen to salvage rhythms that are not a singular and progressive temporality but are unregularised forms of temporal coordination. Listening to salvage rhythms helps us notice more diverse livelihoods and ecologies in shrimp economies too, such as integrated mangrove-shrimp farming and improved extensive shrimp farming. The latter breed shrimp naturally in ways that build local ecologies for example by not using any shrimp feed to reduce the risk of shrimp disease. This perspective reveals how the commodity frontier is composed via patchy landscapes with different forms of shrimp farming.

Second, shrimp economies require social-technical practices of care for water-shrimp-human-environment relations for capital accumulation and disease control so that "*care is a substantial component of the farming economy*" (Harbers, 2010: 156). On farms, to care for animals and water conditions is to optimise the farming economy (Harbers, 2010) and to secure animal welfare. In the farming economy, the human-shrimp relationship is mostly instrumental and hierarchical (cf. Porter, 2019). Yet, at certain moments, breeding shrimp requires meticulous care practices to manage the life of shrimp and water conditions, which are not always dominant but interactive. Ecofeminist water scholars have argued that caring for aquatic animals requires caring for the water (Gaard, 2001; Merchant, 1997). Furthermore, they proposed that care practices should equally consider the need of humans and nonhumans because humans, water, and aquatic animals are interconnected. However, there are uneven power relations between humans and nonhumans in social-technical practices of care.

Care practices include three dimensions: (1) labour/work, (2) affect/affection, and (3) ethics/politics (de la Bellacasa, 2017: 5). First, care is the labour and work of maintenance of animals and things. Second, care involves affection, such as concern and worry for animals and things. Third, care could be an ethical obligation to take responsibility for others' well-being. However, there are tensions among these three pillars. Care is attentive to tensions among caring, suffering, and killing (Haraway, 2007; Harbers, 2010; Mol et al., 2010a). Caring does not necessarily lead to good care. Standards of good care for animals vary in different agrarian, technical, and environmental contexts (Harbers, 2010). Therefore, the ethics of care should not be understood only as normative knowledge and moral obligations. Instead, care involves power relations and many possibilities: how care is offered, to whom and by whom it is offered, and through which modality of handling, are all vital questions (Mol et al., 2010a).

Political ecologists have argued that pathogens and diseases are unseparated components in the agrarian world (Galvin, 2018). Industrial farming systems could be a perfect breeding ground for disease, or so-called disease situations, because of the high density and larger production scale (Hinchliffe et al., 2016: 13-14). Thus, farmers need to care for animals and their living environment. Political ecologists have illustrated economic and ecological contradictions caused by diseases in aquaculture (Bustos-Gallardo and Irarrazaval, 2016; Huang, 2015; Lien, 2015). Like salmon aquaculture, shrimp farming is characterised by three economic and ecological contradictions in relation to shrimp disease: (1) more days in shrimp ponds leads to an increase in shrimp weight but also increases the risk of disease; (2) higher densities of shrimp in ponds yield a higher return on capital but also increase the risk of contagion; (3) and a higher spatial concentration of shrimp farms can reduce production costs but cause ecological exhaustion (cf. Bustos-Gallardo and Irarrazaval, 2016). For example, the lack of wastewater treatment and separated water intake and outflow systems lets wastewater spill over to neighbouring shrimp ponds and increases the risk of shrimp disease. Farmers and companies with their class positions have uneven access to land, capital, and technology to invest in shrimp ponds and cope with shrimp disease. The risk of shrimp disease and profit loss reflects the dilemma of collective action for both family farms and corporations (Huang, 2015). Thus, from hatcheries to labs and shrimp farms, especially intensive and super-intensive shrimp farming, firms put significant effort into practicing biosecurity to secure the life of shrimp and maximise profits.

Biosecurity develops the pathogen-based logic and the anticipatory approach to govern the disease situation (Hinchliffe et al., 2016: 41-47). In so doing, the pathogen-based logic and the anticipatory approach first unpack the disease situation by identifying host-pathogen and environmental interactions in water-pathogen-shrimp-human-environment relations. The pathogen-based logic and the anticipatory approach then focus on two aspects of water-pathogen-shrimp-human-environment relations: elements or their relations. For instance, scientists innovate vaccines and specific-pathogen-free shrimp (SPF shrimp) to improve the immune system of shrimp and secure the health status of shrimp. These biotechnology products focus on shrimp itself. Scientists could also apply probiotics to pond water and shrimp feed to restore microbial symbiosis since they understand the disease situation as a form of microbial dysbiosis. In addition, shrimp buyers in the Global North require that shrimp producers in the Global South should not use antibiotics due to concerns about antibiotic resistance. With this situational and relational approach, biosecurity is more than merely managing pathogens but actively governing water-pathogen-shrimp-human-environment relations.

Third, when animals become 'lively capital', humans encounter not dead objects but fleshy subjects (Haraway, 2007). The formation of shrimp aquaculture is facilitated by domestication (Galvin, 2018). Domestication is defined as plants and animals accustomed to being bred in captivity with human control and care over the organisation of territory and food supply (Cassidy and Mullin, 2007: 5). It controls the life cycle of plants and animals and enrols other organisms in their living environment as well. In domestication, plants and animals are often modified by biotechnologies and widely connected to large industries, such as farming animal feed, agribusiness, and scientific medicine (Haraway, 2007: 62). Thus, domestication is a set of social-technical practices and multi-species relations such that "*all living beings emerge from and make their lives within multi-species communities*" (van Dooren et al., 2016: 2). Humans, in the language of science and technology scholars, are *becoming with* shrimps and other life forms in water because the process of domestication is not only a human endeavour (Haraway, 2007). The life cycle of shrimp is unpacked, disassembled, and reassembled in multiple sites to suit its living conditions and the social worlds of humans. At the same time, humans control the living conditions of nonhumans in order to utilise their liveliness and the mutability of material (cf. Bustos-Gallardo et al., 2021). In summary, shrimp domestication establishes various relations of water-shrimp-human-environment in different life stages in multiple sites to fit with the hydrological cycle for the development of shrimp aquaculture.

2.2.2 Capitalist and more-than-capitalist relations in shrimp economies

In section 2.2.1, I demonstrated how the materiality of shrimp production references (1) the role of nature as obstacle, opportunity, and surprise, (2) socio-technical practices of care, and (3) the heterogeneity and liveliness of species in the context of capitalist technoculture. These concerns about materiality have been primarily examined under capitalist relations. However, shrimp production also involves more-than-capital relations. In shrimp economies, forms of life include both capitalist and more-than-capitalist relations, such as kinship, community ties, and state bureaucracy (Belton et al., 2011). These relations affect and are affected by agrarian, technical, and environmental changes. These relations and changes are widely different, depending on social contexts and political history (Stonich and Vandergeest, 2001: 284). This research considers on two social relations constituted through shrimp economies: class and gender.

In the agrarian political economy, commercial shrimp farming is involved with class relations, the structure of production (smallholder farmers or corporations), and the mode of production (Paprocki and Cons, 2014; Stonich and Vandergeest, 2001). Goss et al. (2001) argue that large companies dominated shrimp aquaculture in Latin America and Indonesia because of their colonial history and legacy. In Vietnam and Thailand, due to successful land reforms or a lack of formal colonialism, the main producer is smallholder farmers, like the livestock industry in Vietnam (Porter, 2019). The history of land reform, such as Land-to-the-Tiller in 1967 in South Vietnam, let small farmers own their lands and have more autonomy so that proletarianisation or depeasantisation are not severe in shrimp aquaculture in Vietnam, unlike in Bangladesh (see Paprocki and Cons, 2014). Although there is an absence of large corporations growing shrimp on-farm and a lack of vertical integration in the shrimp industry in Vietnam and Thailand, corporations indirectly control the production chain in upstream and downstream sectors, such as shrimp feed manufacturing and shrimp processing. On-farm production is a high-risk economic activity, so most of the companies bypass that segment of production and maximise their profits by selling industrial shrimp feed. The risk is transferred to smallholder farmers. Once the disease outbreaks and farmers lose their shrimps, farmers cannot pay back shrimp feed or even have to sell their lands to corporations. Moreover, the Vietnamese government proposes shrimp farming as a poverty alleviation programme for ethnic minorities in the Mekong Delta to shape their subjectivity and livelihood (cf. Li, 2007, 2014; Li and Semedi, 2021).

The shrimp industry operates along existing class lines (Belton et al., 2011). Although both Vietnamese and foreign capitalists do not need to hire a safeguard team to secure their shrimp, like in Indonesia or Central America, they still need to hire workers to breed shrimp. The lives of farmers and workers provide labour to shrimp and capitalists (cf. Blanchette, 2020: 20). Some farmers breed shrimp for themselves but also work for shrimp companies in villages or obtain other jobs in cities to have extra incomes (cf. Harms, 2011). However, capitalists have deep stereotypes about local farmers and workers related to their undisciplined behaviours, such as stealing shrimp feed and equipment. Instead, they prefer workers from other villages or provinces to live in their accommodation on shrimp farms without any local connections (cf. Li and Semedi, 2021: 134). Even though shrimp farming is profoundly shaped by capitalist relations, it is still supported by social ties in villages. In villages in Vietnam, social ties operate along with claims of morality, which is defined by what farmers regard as fair, such as social support or access to resources, sometimes called a moral economy (McElwee, 2007). Shrimp traders and sales agents sometimes provide loans to farmers for buying shrimp feed and equipment (cf. Marks, 2010).

Gender divisions, household economies, and migrant remittance are all aspects of more-than-capitalist relation that supports shrimp economies. Feminist scholars propose that capitalism does not hold a singular, coherent, and totalising logic but is shaped by intimate social relations (Bear et al., 2015). Although shrimp farming is mostly practised by men, women also provide some manual labour on shrimp farms, such as feeding and guarding shrimp. Furthermore, women also indirectly contribute to shrimp economies by giving money to their parents or siblings due to strong family ties in Vietnam (cf. Porter, 2019). Shohet (2021) argues that the family tie in Vietnam has been knit together by moral care and practices of sacrifice (hy sinh) even after the introduction of economic reforms. Thus, when their parents and siblings have economic difficulties with shrimp farming, women often sacrifice themselves by giving money to their families under kin and gender hierarchies in Vietnam. In the Mekong Delta, some young women marry Taiwanese or South Korean men through the introduction of profit-pursuing marriage agents. Under the gendered and patriarchal structure, this international marriage and migration create transnational flows to their families and home country (cf. Faier, 2009, 2013).

Capitalist and more-than-capitalist relations in shrimp farming are profoundly affected by environmental changes. For example, shrimp aquaculture often causes soil salination and mangrove deforestation. Therefore, farmers have fewer livelihood options, decreased community cohesion, and reinforced processes of depeasantization, such as in Kulna's delta region in Bangladesh (Huang, 2015; Paprocki and Cons, 2014; Vandergeest et al., 1999). Furthermore, the combination of ecological and economic instability, such as the outbreak of shrimp disease and the fluctuation of shrimp prices, causes farmers to be exposed to higher environmental and economic risks. The state sometimes plays a crucial role in preventing environmental devastation through land-use planning, such as rice production and mangrove afforestation zones (cf. McElwee, 2016).

This section enriched the notion of hydro-social life within the context of shrimp economies from two aspects: the materiality of shrimp production, and capitalist and more-than-capitalist relations. Attention to materiality shows that water-shrimp-human-environment relations are domesticated, industrialised, and cared for in shrimp economies. On the other hand, hydro-social life is shaped by class relations and gender divisions to support the operation of shrimp economies. These capitalist and more-than-capitalist relations change over time and space along with the materiality and physical environments.

2.3 The multiplicity of shrimp worlds

It is critical to put shrimp economies and hydro-social life into the specific contexts where water and shrimp meet worlds: the hatchery, the delta, and the laboratory. Haraway (2017: 13) suggests that humans and animals are not preexisting but always encountering one another via their intertwined worldings. For Haraway, worldings is like playing string figure games, which need giving and receiving patterns between humans and nonhumans. Shrimp worlds are contact zones that shed light on the interactive communication and improvisational practices between humans and nonhumans. Although animals are grown as commodities on the frontier, water-shrimp-human-environment relations are often being reconfigured across several different contact zones. Understanding these dynamics requires situating them in particular sites of encounter: the hatchery, the lab, and the delta. Thus, this section draws on delta studies and STS approaches for a richer understanding of how shrimp worlds are constituted across these multiple sites.

2.3.1 Hydro-social life in the hatchery

In political ecology and STS, hatcheries are considered as a node of animal reproduction within commodity chains and wildlife networks (Hamada, 2020; Lien, 2015; Nustad and Swanson, 2021; Taylor, 1998; Whatmore, 2002). The hatchery captures broodstocks from the wild and brings them into rearing tanks for interbreeding. However, the hatchery operates with a different logic for fishing and aquaculture. In the fishing industry, hatcheries release larvae to the wild, such as rivers and seas, to restore the wildlife population and to compensate for the amount of fishing. Thus, some political ecologists focus on how the hatchery and their stock enhancement programmes blur the boundary between domestication and wilderness (Berseth and Matthews, 2021; Swanson, 2019; Swanson et al., 2018). The release of hatchery animals might impact the genetic diversity of the wildlife population and ecosystem due to genetic selection and artificial rearing. By contrast, the aquaculture industry releases larvae into enclosed spaces, such as salmon farms or shrimp ponds. Other political ecologists emphasise how the hatchery operates as an engine driving aquaculture development (Hinchliffe et al., 2018; Lien, 2015). The hatchery domesticates and reproduces animals commercially and provides postlarvae for farmers and labs.

In the history of science, Taylor (1998) argues that it is critical to examine how the formation of the hatchery has been influenced by social and political contexts. Since the 19th century, the hatchery, especially in the salmon industry, has been a site of innovation across many continents (Swanson, 2013). Scientists, technicians, certain species, and breeding technologies unevenly travelled across countries, such as the USA, Norway, Australia, Japan, Taiwan, and Chile. Initially, hatcheries were operated as a laboratory to unpack the life cycle of animals and draw certain species into this space. Later, hatcheries created an animal domus (animal's house) in the field to breed animals in high density and explore commercial models (Lien, 2015). Although the hatchery seems to be a human-dominated place, it requires workers to attune their bodies to animal bodies and/or stimulate certain animal behaviours by creating an animal atmosphere (cf. Lorimer et al., 2019).

2.3.2 Hydro-social life in the delta

Deltas are places where humans and nonhumans, waters and land, seawater and freshwater meet (Krause and Harris, 2021). Deltas facilitate and impede the formation and operation of shrimp economies in multiple ways. Meanwhile, shrimp economies shape the deltaic environment into a production site by installing devices and constructing infrastructure for water management.

In recent years, anthropology has developed delta studies, or so-called "amphibious anthropology", to analyse hydro-social lifeworld at the land-water interface (Jensen, 2017; Krause, 2017). Delta studies offer three key insights on how to read these amphibious environments that inform this research. First, *delta as a backdrop*: in this approach, scholars have mainly focused on practices of agriculture and extraction with the delta functioning as a background to human activities (Watts, 2001, 2004; Shoreman and Haenn, 2009; Williams, 2018). Second, *delta as a capricious environment*: in this approach, scholars have focused on deltas as an unstable and vulnerable landscape because of shifting river courses and the proximity of wetlands. Scholars have also noticed how wet and dry seasons, seasonal flooding, and variations of salinity influence farmers' livelihoods and how market, institutions, and social factors amplify natural impacts or enhanced abilities of farmers (Hoque et al., 2017, 2018; Shinn et al., 2014). For instance, farmers in the Mekong Delta are facing climate-related impacts, like abnormal rains, high temperatures, and water scarcity, to rice and shrimp production (Brown et al., 2018). Third, *delta as an infrastructuralised object*: in this approach, scholars have identified how both the state and residents install devices and construct infrastructure upon the delta to engineer and stabilise the deltaic landscape. Researchers have analysed how deltas, on a regional scale, are shaped by states, engineers, and laypeople with diverse technologies and infrastructures, like levees, pumps, sluice gates, irrigation, and drainage system, under various social and political contexts (Ward, 2001; Barnes, 2014; Benedikter, 2014; Morita, 2016). Humans objectify and infrastructuralise deltas as natural resources that can be tamed and utilised. Meanwhile, the materiality of the delta, such as sand and salinity, could impede the delta from becoming an infrastructured object. Reading the Mekong Delta as both a capricious environment and an infrastructuralised object rather than simply as a backdrop brings the background into the foreground (Hetherington, 2019: 6). The delta becomes an active agent influencing hydro-social lives. There is also a tension here between the capricious environment and the 'infrastructuralised object' perspectives, since the scale and materiality of the deltaic environment cannot be fully infrastructuralised by humans.

Shrimp farming is embedded in the wetness, rhythms, and volatility of deltas. First, the notion of wetness captures fluid and dynamic worlds (also see Bhattacharyya, 2019; Krause, 2021; Lahiri-Dutt and Samanta, 2013; Steinberg and Peters, 2015; Whitt, 2018b). Amphibious landscapes are so dynamic and capricious that inhabitants adjust their lives to fit with the environment. Second, rhythms reflect how '*social and ecological life develops simultaneously cyclically and historically*' (Krause, 2017: 406). These rhythms include water flow, animal movements, and economic cycles. Third, the idea of volatility is to describe the rapid changes and movements in both social and material configurations. Compared to rhythms, volatility emphasises unpredictable changes in a short period rather than cyclical fluctuations in a long period. The rhythm and volatility of nature and economies constantly interfere with each other. When rhythms and economies are not synchronised well, the politics of cyclic dissonance or economic crisis happen (see Whitt, 2018a).

Although shrimp farming is profoundly affected by the temporality and spatiality of the delta, shrimp economies can shape them by installing small devices and constructing mega-infrastructure (Furlong, 2010). From a Marxian political economy perspective, small devices and infrastructure are the means of production that shape deltaic environments into more productive lands. On the regional scale, hydraulic infrastructure, such as canal and sluice gates, are constructed and managed by the state power (Benedikter, 2014b; Evers and Benedikter, 2009). On the local scale, farmers and companies utilise small devices to manage water quantity, quality, and ecology. Infrastructure and devices are mediums for nonhuman life to construct their habitat, facilitate certain behaviours, and manage desirable multi-species relations (Barua, 2021; Morita, 2017). Furthermore, devices and infrastructure show how human and nonhuman relations are produced and sustained in the hydro-social cycle (Swyngedouw, 2015: 30).

2.3.3 Hydro-social life in the laboratory

Science and technology studies (STS) has long been discussing the role of the laboratory in knowledge production, commodity innovation, and disease prevention. In STS, laboratory studies has shifted their focus from the construction of scientific knowledge, the relations between scientific and lay knowledge, to laboratory animals. Hess (2007) generalises that the first generation of laboratory studies focuses on the construction of scientific knowledge in controversies (Knorr Cetina, 1999; Latour and Woolgar, 1986; Pickering, 1995); the second generation focuses on the juxtaposition of scientific knowledge and lay knowledge beyond labs to tackle social problems (Callon et al., 2011; Fortun, 2001; Kleinmam, 1998; Stephens and Lewis, 2017). This research pushes it further toward laboratory animal studies. The laboratory is one of the major sites where humans and animals meet (a kind of intimate interspecies encounter) (Haraway, 2007: 84). Laboratory animal studies focuses on skilled care, animal welfare, and human-nonhuman relations (Druglitrø, 2018; Greenhough and Roe, 2019; Haraway, 2007; Sharp, 2018; Suzuki, 2021).

Laboratory studies has analysed the process of laboratorisation (to use Knorr Cetina's term) by which the complex relations encountered in the field are simplified (Knorr Cetina, 1999: 30). Labs create a distinctive hydro-social life, which is different from that for farmers in the fields and from hatcheries, yet critical to shrimp economies. By bringing shrimp into labs, shrimp are turned from natural to analytic animals and machine-like tools that function as part of scientific infrastructure (Druglitrø, 2018; Johnson, 2017; Keck, 2015; Lynch, 1988). The laboratory becomes a nursery where animals are bred, maintained, observed, and surrounded by equipment (Knorr Cetina, 1992: 127). In the lab, the operation of experiments is supported by a labour hierarchy

(Sharp, 2018). Experiments are designed by scientists and conducted by technicians. Laboratory animals and their living conditions are cared for and managed by technicians and workers for scientific research. This instrumental relation between science and experimental animals is key to enlarging an account of shrimp economies, which renders their life form itself a potential commodity in the capitalist forms of life that organise testing and experimental tasks. The instrumental relation also shows an asymmetrical power relation between humans and shrimp.

In political economy and STS, labs are an essential site for understanding shrimp disease and industrialising organisms through macro-biotechnologies and micro-biotechnologies (Pemberton, 2003). Labs breed specific-pathogen-free larvae, design shrimp feed, and develop vaccines and probiotics to create new possibilities for shrimp economies. The lab introduces not only shrimp but also other species, such as viruses and microbes, for biosecurity experiments. In shrimp aquaculture, labs are active in experimenting with probiotics, which Lorimer (2020) describes as using life to manage life. Keck (2015) argues that the logic of biosecurity and the logic of care intersect differently in the lab and on the farm. The laboratory intentionally infects the lab animal, so-called disease challenges, to analyse the cause of shrimp disease and produce biosecurity knowledge. Lab innovations need to spread outside in the real world, such as field trials (Henke, 2008). Although having done many trials and experiments in laboratories, scientists and companies still need to make their solutions practical and innovations commercially viable for biosecurity in the field. However, unlike a well-controlled laboratory environment, there are more uncertainties in fields, which require different managements, such as disease management, pathogen management, and immuno-preparedness (Hinchliffe et al., 2016: 124-132). Furthermore, biosecurity is not always produced by scientists in the lab. Farmers and capitalists can develop biosecurity by improving their pond design and management at an affordable cost. Therefore, it is crucial to examine biosecurity practices beyond the lab.

Laboratory animal studies argue that laboratory animals are lively working subjects and suffer from experiments, which leads to issues of animal ethics (Greenhough and Roe, 2018, 2019; Haraway, 2007; Sharp, 2018). For instance, this work focuses on the care skills, animal welfare, and affective moments for laboratory animals (Greenhough and Roe, 2010, 2018, 2019; Johnson, 2015; Message and Greenhough, 2019; Roe and Greenhough, 2021; Sharp, 2018). Laboratory animals are more than a tool, an instrument, or research objects. Even though shrimp are used as research animals for the health of shrimp and the interest of growers under instrumental analysis, they still require humans to respond to them for their pain and suffering (Haraway, 2007: 72). Haraway (2007: 89) suggests that we have to understand the heterogeneous beings in the experiment rather than holding a transcendent idea of Human and animal rights. In labs, technicians are the key actor in taking care of research animals and killing them responsibly. They attune their bodies to animal bodies and improve animal welfare by tinkering (cf. Giraud &Hollin, 2016; Mol et al., 2010b). Suzuki (2021) suggests that good care for laboratory animals could be defined by broader ethical, institutional, organisational, cultural, and religious contexts.

2.4 Conclusion

This chapter developed a conceptual framework for analysing shrimp economies and hydro-social life, and contextualised these concepts across three contact zones. First, this research developed the notion of hydro-social life by adopting the concept of hydro-sociality from water research. The concept glues together biological life forms and social forms of life to analyse the entanglement of water and life in bioeconomies. In so doing, this research developed the writing of water-shrimp-human-environment relations as a way of unpacking the components and relations that underpin shrimp aquaculture in different settings. Hydro-social life needs to be contextualised in shrimp economies in order to tell stories of how water-meets-worlds.

Second, this chapter brought the concepts of hydro-social life and shrimp economies into relation with work in political economy and political ecology on shrimp production. In doing so, it has sought to emphasise two features of shrimp economies that have been overlooked in previous accounts: the more-than-human materialities of shrimp production and the more-than-capitalist relations through which shrimp production is sustained. In terms of materiality, this chapter has shown how the hydro-social life of shrimp aquaculture is constructed through (1) nature as obstacle, opportunity, and surprise, (2) social-technical practices of caring for shrimp, and (3) the heterogeneity and liveliness of shrimp. As for capitalist and more-than-capitalist relations, forms of life in shrimp economies are shaped by class conflicts in production and gender divisions in households.

Third, I contextualised shrimp economies and their hydro-social lives by reference to three key contact zones where water and shrimp meet worlds: the hatchery, the delta, and the laboratory. Drawing on delta studies and STS approaches, this research analyses how water-shrimp-human-environment relations are sustained and reconfigured across these three sites for shrimp reproduction, shrimp growth, and scientific research.

Chapter 3. Research Design and Methodology

This chapter explains my research design. Section 3.1 adopts multi-species and multi-sited ethnography to design field site selection and the timing and duration of fieldwork. I develop multi-species and multi-sited ethnography as approaches by tailoring these research methods for context-specific details — such as the use of delta methods to study shrimp ponds in the delta, and laboratory ethnographic methods in relation to the scientific laboratories — to properly observe hydro-social lives and multi-species relations in the hatchery, the delta, and the laboratory. Section 3.2 outlines the research process and elaborates on data collection and ethical concerns. I conducted 12 months of ethnographic work across multiple sites in Vietnam by adopting participatory observation, semi-structured interviews, and secondary data analysis techniques. I utilised my personal network, connected with a grassroots group, and mobilised my national identity to get access to my field sites. Section 3.3 illustrates my personal experience with how a foreign researcher conducts fieldcraft in Vietnam. As a one-party socialist country, Vietnam has stringent regulations on foreign researchers, especially in rural areas. I reflect on my positionality in the field and consider how these significantly shaped my access to the field and data collection.

3.1 Doing multi-species and multi-sited ethnography

This research aims to analyse shrimp economies and hydro-social lives across multiple different sites. Thus, this project combines multi-species and multi-sited ethnographic approaches to track shrimp in different spatial-temporal contexts and observe the operation and influence of shrimp economies. Multi-species ethnography is a useful mode of writing to record multi-species relations, including but not limited to the entanglement of humans and nonhumans, in shrimp domestication, shrimp farming, and shrimp experimentation. Multi-species ethnography foregrounds nonhuman agency rather than viewing nonhuman species as merely resources for the lives of humans and is especially valuable in agrarian worlds (Blanchette, 2020; Galvin, 2018; Lien, 2015; Porter, 2019). To capture multi-species relations requires the arts of noticing and attentiveness and researchers must learn to be curious and affected by other species (Tsing, 2011; van Dooren et al., 2016).

Multi-species ethnography can benefit from a multi-sited ethnographic approach by following species on the move (Kirksey and Helmreich, 2010). Marcus (1995) suggests that following the thing is a mode of constructing a multi-sited ethnography. In practice, following the thing is actively shaped by the field as the researcher ultimately takes one path among many options (Coleman and Hellermann, 2011). This path is the outcome of judgments about research questions and situations in the field, such as when to visit labs versus when to spend time in hatcheries or with farmers during shrimp harvests. As a consequence, multi-sited ethnography acknowledges that perspectives are always only partial and that knowledge is situated and distributed rather than omniscient (Haraway, 1988; Marcus, 1995). It does not mean that the analysis of multi-sited ethnography is less solid or valuable. Marcus (2011) suggests that the relative thickness and thinness of a research site depend on the theoretical question being asked and fieldwork pragmatics.

The selection of research path and the thickness and thinness of analysis are related to research questions (see Chapter 1, section 1.1.3). This research analyses the formation, operation, and influence of shrimp economies. In shrimp economies, the hatchery nurtures broodstocks and propagates larvae for the shrimp farm in the Mekong Delta; the shrimp farm grows and harvests shrimp in various marketable sizes; the laboratory tests and experiments with shrimp for knowledge production and commodity innovation. During my fieldwork, I encountered humans (farmers, workers, capitalists, and scientists) and nonhumans (shrimps, algae, viruses, and bacteria) in the hatchery, the shrimp farm, and the laboratory. These sites are not discrete but connected nodes in the commodity cycle of shrimp economies. The thickness and thinness of these research sites are also determined by the accessibility and social relationships with informants in the authoritarian context (see section 3.4).

The mode of writing is crucial for multi-species and multi-sited ethnography to capture multi-species relations and to set the scene in relation to field sites. Multi-species ethnography treats nonhumans as ethnographic subjects by drawing on humanities, social and natural sciences approaches to make them thick on the page (Kirksey, 2014; Tsing, 2015; Haraway, 2017). Writing multi-species ethnography encounters a fundamental question: how to represent nonhumans? This question refers to the problem of voice (speaking for and speaking to) and the problem of place (speaking from and speaking of). Kirksey and Helmreich (2010) suggest the deadlock of representation can be undone by blurring the boundary between human and nonhuman to rethink natural and cultural categories. Multi-species ethnography often writes in a storytelling style or uses art and technoscience to challenge this boundary (Haraway, 2015; Lien, 2015; Tsing, 2015; van Dooren, 2016, 2019). Although this research does not write in the storytelling style as other multi-species ethnographies have done, it includes several local vignettes describing how various forms of multi-species relations take shape in the hatchery, the shrimp farm, and the laboratory.

Since my multi-species and multi-sited ethnography unfolds across diverse spatial and temporal phenomena, each research site requires tailoring methods to different context-specific details. In the following, I will review delta methods and laboratory ethnography applied in either specific or all the field sites. All these methods help to describe the distinctive hydro-social life in the sites and to connect them to capture the formation, operation, and influence of shrimp economies.

3.1.1 Delta methods and laboratory ethnography for the hatchery

The hatchery does not have a unique research method but can be analysed with a combination of delta methods and laboratory ethnography. In the history of shrimp domestication, shrimp were laboratory animals, and hatcheries were a critical site to research the physiology and life cycle of shrimp. In the contemporary context, hatcheries are a commercial space for shrimp reproduction. Hatchery owners collect wild broodstocks or purchase them from other lab-like hatcheries to propagate and supply larvae for shrimp farms. During the reproduction process, hatcheries still conduct biosecurity to the laboratory standard. Even though hatcheries exert strict biosecurity within tanks and buildings, they are still embedded in the broader environment. Their operation is shaped by the water quantity, quality, and movement in the delta. Thus, delta methods are useful for analysing the relationship between the hatchery and the delta.

3.1.2 Delta methods

This research engages new subfields that combine ethnographic research with a particular focus on deltas — sometimes known as delta methods (Krause, 2018a; Morita and Suzuki, 2019; Krause and Harris, 2021) — to contextualise the unique spatial and temporal dynamics of these environments. Delta methods are an approach to contextualise existing research methods and describe rhythmic patterns, wetness, and violent transformations in deltas (cf. Biggs, 2012; Lahiri-Dutt and Samanta, 2013; Barnes, 2014; Morita, 2016; Bhattacharyya, 2019). In this sense, they are methods that require understanding the particular features of deltas rather than being a toolbox of methods that one can learn about without empirical context (Krause, 2018b). This research contextualises participatory observation and semi-structured interviews in the deltaic environment by comparing four kinds of commercial shrimp farming in rainy and dry seasons in the Mekong Delta. Each kind of farming has a distinctive hydro-social life, which is shaped by the spatiality and temporality of the delta.

Doing fieldwork in the Mekong Delta led me to think closely about human-environment relations. Compared to the massive delta landscape, individual humans are so small that we cannot directly observe holistic change at the landscape scale and can only partially experience natural forces (Morita and Suzuki, 2019). This fundamental difficulty of researching the delta, then, leads us to the notion of situated knowledge and recognition of the limits that partial perspectives and particular locations have on research (Haraway, 1988). One’s position amid the delta landscape grounds knowledge around a particular perspective, which is itself mediated by the research tools and devices employed in research, such as maps, historical documents, scientific studies, and so on. In *Delta Methods*, Krause (2018b) argues that ethnographers can zoom out from their field sites to see broader contexts and think about hydro-social life at multiple scales with various research tools. This research adopts multi-sited ethnography to collect various situated perspectives in order to depict the broader deltaic environment.

Delta methods investigate how the physical and social positionality of stakeholders shape hydro-social lives and cause agrarian changes in different parts of the Mekong Delta. This research teases apart the set of elements that constitute shrimp economies, such as the materiality of the delta, the character of shrimp species, class relations and gender divisions (cf. Li, 2014: 16). This research worked with a range of stakeholders, such as farmers practising integrated mangrove-shrimp farming and urban elites and foreign companies doing super-intensive shrimp farming. The positionality of these social groups shapes their valuations of water and decision-making about water management (Ioris, 2012). Out of these physical and social positions, they produce new histories and conjunctures as they organise supply chains and coordinate inputs of labour and capital for new farming operations.

The temporality of the delta affects hydro-social lives and research methods. I visited shrimp farms in both dry and wet seasons. I also observed how different stakeholders practise shrimp farming and cope with changes in water quantity and quality. For instance, shrimp harvesting in mangrove forests depends on the rhythm of nature. Farmers harvest shrimp during the low tide at midnight on the 15th or 30th day from the 3rd to 8th lunar month. I had to arrange my schedule to fit with the lunar calendar, the farmer's schedule, and government bureaucracy. As a foreign researcher, I had to apply for research permits three weeks before the field trip, especially staying in mangrove forests in restricted areas overnight and waiting for research permission from the local government. Due to governmental regulation, it was challenging for me as a foreign researcher to visit shrimp harvesting in the mangroves. It is these types of social, political, biophysical, and even planetary rhythms (i.e. lunar cycles) that make delta methods unique and important areas of research.

3.1.3 Laboratory ethnography

This research conducts laboratory ethnography to capture hydro-social lives, such as knowledge production, commodity innovation, and human-animal relationships, in the laboratory. Knowledge production and commodity innovation usually involve more than one laboratory and occur across the whole scientific field (Collins, 1985; Knorr Cetina, 2001: 161). Researchers have conducted their fieldwork in academic and university labs (Kleinmam, 1998; Henke, 2008; Myers, 2015; Sharp, 2018). However, commercial, industrial, and governmental labs also provide scientific services, produce knowledge, and innovate commodities. University labs either work with or are funded by companies and governmental sectors (Kleinmam, 1998; Henke, 2008). This research visited various kinds of labs, such as university labs, private labs, an Aquaculture Research Institute, and governmental diagnostic testing stations for aquatic animals (Trạm Kiểm dịch Thủy sản). These labs carry out different tasks, like testing shrimp disease, conducting experiments, or innovating products, to underpin shrimp economies.

The task of the lab is determined by their scale of capital and labour. Sharp (2018) proposes the notion of lab labour hierarchies to describe the work and division of labour within labs. In lab labour hierarchies, scientists usually design research projects, while animal technicians are the critical caregiver practising hard work for projects and emotional labour for lab animals (Svendsen and Koch, 2013; Sharp, 2018; Greenhough and Roe, 2019; Message and Greenhough, 2019). This research works with scientists, well-trained technicians, and workers without academic backgrounds to capture the labour division that supports hydro-social life in labs.

Positionality in laboratory ethnography is related to the politics of 'studying up', where one's informants are experts in their disciplinary fields and there are gatekeepers to communities (Law, 1994: 36-37; Mukherjee, 2017; Stephens and Lewis, 2017). The politics of studying up shapes power relations between researcher and researched. For instance, ethnographers may be uncomfortable or anxious in labs. The appearance of researchers in the lab can be a bit awkward for both sides. It also presents limits to research because "*you can't ask about something if you don't know it exists*" (Law, 1994: 44). Upskilling of scientific knowledge and building up rapport with technicians might be able to solve these problems. For example, in her ethnography, Myers (2015) observed several undergraduate and postgraduate courses, attended professional conferences, and read scientific papers to obtain further knowledge in protein crystallography. I learned and researched the life cycle of shrimp and the history and practices of shrimp economies by reading (1) aquaculture textbooks, like *Marine Shrimp Culture: Principles and Practices*, and *Shrimp Culture and Disease Control Strategy*; (2) journal articles from *Scientific Reports*, *Fish & Shellfish Immunology*, and *Developmental and Comparative Immunology*; and (3) aquaculture magazines, including Global Seafood Alliance websites, Shrimp News International and Tập chí Thủy sản.

3.2 Data collection and research ethics

This research collected data through participatory observation, semi-structured interviews, and second-hand data analysis. I was allowed to conduct participatory observation with gatekeepers in certain circumstances due to the availability of field sites and governmental regulations (see section 3.4). I adopted semi-structured interviews when I could not stay in the field for a longer period. Secondary data were collected from news articles, company reports, aquaculture magazines, and governmental websites for the interview preparation and policy analysis.

The fieldwork was conducted from September 2019 to October 2020 during the COVID-19 pandemic in Vietnam (Hồ Chí Minh city, Cà Mau, Bạc Liêu, Sóc Trăng, Bến Tre, and Ninh Thuận). From March to April 2020, Vietnam was facing the first wave of COVID-19 and had a national lockdown for six weeks. This research was relaunched at the end of April in a laboratory in Hồ Chí Minh City and revisited the Mekong Delta from June 2020. In August 2020, there was a second wave of COVID-19 and a regional lockdown in Central Vietnam, but the Mekong Delta was not affected, and the local governments still allowed me to conduct research.

3.2.1 Participatory observation

To conduct participatory observation, I built up rapport with informants by three methods: mobilising my personal networks, connecting with grassroots community groups, and utilising my national identity. Through these methods, I diversified my gatekeepers and field sites to gain access to different opinions in each of my research sites (Table 4). All informants' names (below) are anonymised. Building rapport with the informants influenced the length of time I was able to stay in the research sites and my access to activities. I built up strong friendships with some of my informants so that I could revisit them several times.

First, I became acquainted with some informants through my social network. Some of my acquaintances in Vietnam and Taiwan have relatives or friends doing shrimp farming in the Mekong Delta. Through their introduction, I visited their relatives and their family, and observed them for a longer time. Once I shared my research project with my Taiwanese friend, and she then introduced Phương, her aunt, to me. Phương is a Cambodian Vietnamese from the Mekong Delta, who married a Taiwanese man through commercial marriage and lived in Taiwan. Her parents are doing intensive shrimp farming in the Mekong Delta. I contacted Phương on Facebook while I was in Vietnam.

Table 4 List of informants for participatory observation[3]

Name (pseudonym)	Information about the Informants	The Date of Interview	The Place of Interview
Farmer			
Thành	a Cambodian Vietnamese farmer and his family in Bạc Liêu	February 28th-March 1st, 2020 June 19th – 23rd, 2020 September 26th-28th, 2020	Thành's house; Thành's shrimp farms; a village in Bạc Liêu
Nghĩa	a Vietnamese farmer in Cà Mau	October 1st-2nd, 2020	Nghĩa's shrimp farms in Cà Mau

[3] All informants' names have been anonymised

Government			
Sơn	a Vietnamese civil servant in Cà Mau	June 29th and July 1st-2nd, 2020 August 17th-21st, 2020 October 1st-2nd, 2020	villages in Cà Mau; hydraulic infrastructure field trip in Cà Mau
Care for Mangrove (NGO)			
Dũng	the project manager in Cà Mau	October 17th, 2019 June 29th-30th, 2020	NGO's local office in Cà Mau
Shrimp breeding and processing company			
Ming-Yi	the chairman of the Taiwanese shrimp breeding and processing company	November 12th- 14th, 2019 March 8th, 2020 March 21st, 2020 July 18th, 2020 August 1st-2nd, 2020	his factory in Long An; shrimp farms in Bến Tre; restaurants in Hồ Chí Minh City
Wei-Ting	a Taiwanese senior technician on Ming-Yi's shrimp farm	March 21st, 2020 July 18th, 2020 August 1st-2nd, 2020	shrimp farms in Bến Tre
Scientists			
Dr Anh	a Vietnamese scientist in a shrimp laboratory	March 26th, 2020 April-October, 2020	Ming-Yi's factory; Dr Anh's lab
Hoa	a Vietnamese technician in a shrimp	April-October, 2020	Dr Anh's lab
Lộc	a Vietnamese technician in a shrimp	April-October, 2020	Dr Anh's lab

Source: Author

However, Phương did not allow me to visit her parents until our first meeting in Taiwan. After that, Phương trusted me and called me her younger brother and suggested I call her my older sister. This indicates that we built up trust and kinship.[4] With this

[4] In Vietnamese, speakers use different titles to determine their social position and their relationships with listeners.

new identity, I became a member of Phương's family and gained a position in her Vietnamese village. In Vietnam, family kinship marks social position and influences who I could meet in Bạc Liêu (cf. Chang, 2019). In February 2020, I visited Thành, Phương's father, at Bạc Liêu bus station. Thành has four daughter. Except for Phương, now living in Taiwan, the other three daughters and their husbands are doing intensive shrimp farming in the same or nearby villages. Thành introduced me to all his daughters and their husbands. I visited Thành and his family in Bạc Liêu three times. Thành generously shared with me his farming experience and family stories.

Building up a friendship with civil servants helped me reach more field sites. After the first field trip to Cà Mau, I built up a friendship with Sơn, a Vietnamese civil servant. He accompanied me to interview farmers, helped me cope with police officers, introduced his friend to me, and guided me to several hydraulic infrastructures. I shadowed Sơn in Cà Mau for five days. Sơn organised a tour of hydraulic infrastructure for me to see the water management in Cà Mau. Once we finished the field trip, Sơn told my driver to visit Nghĩa, his university roommate, in the village. Nghĩa is the vice-principal of a local high school and does shrimp farming in his spare time. Through this network, I was invited to observe the shrimp harvesting in the mangrove forest on the next field trip.

Second, working with grassroots community groups is another opportunity to get into the field (Scott et al., 2006). I worked with Care for Mangrove (CfM, pseudonym), an international NGO that has been prompting ecosystem service payments for local farmers in the mangrove forest in Cà Mau for eight years. In September 2019, I met the project manager in CfM in Hồ Chí Minh city. The project manager introduced her colleague Dũng and arranged a field trip for me with a research permit. Before working in CfM, Dũng was a public servant in the Vietnam Administration of Forestry. On my first trip to Cà Mau, the Cà Mau government did not assign a civil servant to me. Dũng was the gatekeeper and introduced farmers enrolled in their project. On my first trip, Dũng told me that he also does shrimp farming in Cà Mau and shares his mangrove shrimp pond with his older brother. In my second field trip, I visited Dũng's shrimp pond to explore this diverse class position.

Third, my national identity provides me with a unique position among foreign researchers to enter the shrimp industry in Vietnam. As a Taiwanese national, I contacted Taiwanese shrimp companies and extended my social network along with their business in Vietnam. From the 1970s to the 1980s, Taiwan was a black tiger shrimp production empire. However, due to the outbreak of shrimp disease, Taiwanese entrepreneurs moved to Vietnam. In October 2019, the director of Taiwan Trade Centre, Representative Office in Hồ Chí Minh City, introduced me to Ming-Yi, the chairman of a Taiwanese shrimp breeding and processing company in the Mekong Delta. Since the 1990s, Ming-Yi has been running his shrimp processing company and expanding his business to shrimp farming. Ming-Yi studied business at National Taiwan University, where I obtained my bachelor's and master's degrees. The alumni relationship and my British PhD candidate identity became social and cultural capital to build a long-term working relationship with Ming-Yi. Ming-Yi often invited me to visit his shrimp ponds in Bến Tre and attend his business meetings. We had several discussions about his business. Through shadowing Ming-Yi, this research was able to explore how foreign capital settled in the Mekong Delta and shaped the operation of shrimp economies through the practice of super-intensive shrimp farming.

In a business meeting, Ming-Yi discussed a cooperation plan with Dr Anh, a Vietnamese aquaculture scientist, for his business. I took this opportunity to exchange my business card with Dr Anh. I visited Dr Anh's shrimp laboratory in Hồ Chí Minh city another day. Although Dr Anh is a scholar at a national university, he owns a private laboratory, hatchery and shrimp ponds outside the campus. After the first interview in Dr Anh's office, he allowed me to conduct laboratory ethnography in his lab and hatchery with technicians (Hoa and Lộc) and workers to learn the operation of shrimp experiments. I visited Dr Anh's in Hồ Chí Minh city many times from April to October 2020.

Fieldnotes are usually taken as jottings *in situ* or during the evenings of the field trips. I learned Vietnamese during my fieldwork in Vietnam (more details in section 3.3.2). The field notes are written in Vietnamese with some Chinese notes. Keeping notes in Vietnamese helped me to explore indigenous meanings in Vietnamese. After fieldwork, I rewrote these notes into longer field notes at my desk. Although the fieldnotes are mainly about shrimp farming and the hydro-social life of informants, I also stayed open to other details to broaden my research scope. While rewriting my fieldnotes, I reconstructed the scenes of activities, informants' feelings and reactions, and my feeling and thoughts. Photos and videos were taken with permission.

3.2.2 Semi-structured interviews

This research interviewed 48 informants, including 13 farmers, an NGO staff member, 6 scientists, 17 civil servants, 5 workers in shrimp companies, 5 shrimp hatcheries, and a shrimp buyer (Table 5). Generally, there are six types of interviews. First, I interviewed farmers doing four kinds of shrimp farming to understand their farming practices (Figure 5). Most farmers were introduced by CfM and other farmers were brought in by my Vietnamese teacher and a Vietnamese sales agent of a Taiwanese shrimp feed company. Second, I interviewed a project manager of CfM to know the practice of integrated mangrove-shrimp farming. Third, I visited Taiwanese scientists to explore the scientific research in shrimp pathology and SPF shrimp. Fourth, I interviewed civil servants in the Department of Irrigation, the Department of Fisheries, the Department of Environmental and Natural Resources, the Research Institute of Aquaculture, the Agricultural Seed Centre, and the Cooperative of Brine Shrimp Farming in Bạc Liêu and Cà Mau. Through these interviews, I explored how state policies shaped the aquaculture industry and water management in the Mekong Delta. Fifth, I visited Taiwanese shrimp feed companies and Vietnamese sales agents to figure out how supporting industries, such as shrimp feed and medical products, shaped the operation of shrimp aquaculture and social relations in villages. Sixth, this research visited private and governmental shrimp hatcheries in the Mekong Delta and Ninh Thuận to learn the technique of artificial propagation.

The interviews were mainly conducted in informants' offices or houses. I mostly interviewed informants, like farmers, workers, technicians, civil servants, and sales agents in Vietnamese but interviewed other informants, such as scientists and shrimp feed companies, in English or Mandarin. Before doing interviews, I always wrote my questions down, printed them out, or even provided them to my informants in advance. The spelling and grammar of Vietnamese were checked before the interviews to ensure that my informants could understand my questions.

Table 5 List of informants for semi-structured interviews[5]

Name (pseudonym)	Information about the Informants	The Date of Interview	The Place of Interview
Farmers			
Phương	a Cambodian Vietnamese from the Mekong Delta, married a Taiwanese man through commercial	December 22nd, 2019 December 19th, 2020 March 10th, 2020	an apartment store in Tainan, Taiwan

[5] All informants' names have been anonymised

	marriage and lived in Taiwan		
Nam	a Cambodian Vietnamese farmer	June 21st, 2020	Nam's house in Sóc Trăng
Hoàng	a Cambodian Vietnamese farmer	June 21st, 2020	Thành's house in Bạc Liêu
Long	a Chinese Vietnamese brine shrimp farmer	February 29th, 2020 June 23rd, 2020	Long's shrimp farm in Bạc Liêu
Trúc	a Kinh Vietnamese farmer	July 3rd, 2020	Trúc's house
A	a Kinh Vietnamese	October 18th, 2019	farmer's home in Cà Mau
B	a Kinh Vietnamese	October 18th, 2019 June 29th, 2020	farmer's home in Cà Mau
C	a Kinh Vietnamese	October 18th, 2019	farmer's home in Cà Mau
D	a Kinh Vietnamese farmer (an urban elite)	June 22nd, 2020	a café in Bạc Liêu
E	a Kinh Vietnamese farmer	June 22nd, 2020	the farmer's house in Bạc Liêu
F	a Kinh Vietnamese farmer	June 29th, 2020	the farmer's house in Cà Mau
G	a Kinh Vietnamese farmer	June 29th, 2020	the farmer's house in Cà Mau
H	a Kinh Vietnamese farmer	June 30th, 2020	the farmer's house in Cà Mau
Care for Mangrove (NGO)			
I	the project manager	October 4th, 2019	NGO's office in Hồ Chí Minh City
Scientists and technicians			
Mei-Yu	a Taiwanese scientist	December 7th, 2019	Mei-Yu's office at a university
Si-Ting	a Taiwanese scientist	December 21st, 2020	Si-Ting's office at a university
Wen-Hua	a Taiwanese scientist	December 24th, 2020	a hatchery in Hualian
Chung-I	a Taiwanese scientist	December 31st, 2019	an office at a

		December 10th, 2020	university
J	a Taiwanese senior technician	December 23rd, 2019	an aquaculture research institute in Pingtung
K	a Taiwanese scientist	December 23rd, 2020	a convenient store in Pingtung
Government			
L	a civil servant in Forestry Management Board	October 18th, 2019 June 29th, 2020	the office of the Forestry Management Board
M, N, and O	civil servants of the Department of Environmental and Natural Resources, Cà Mau	July 1st, 2020	the governmental office
P	a civil servant of the Department of Fisheries, Cà Mau	July 1st, 2020	the governmental office
Q	civil servants of the Agricultural Seed Centre, Cà Mau	July 2nd, 2020	the governmental office
R	the vice-principal of the Research Institute of Aquaculture	July 2nd, 2020	the Research Institute of Aquaculture in Cà Mau
S	civil servants of the Department of Irrigation, Cà Mau	August 19th, 2020	the governmental office
T, U, and V	The vice director and civil servants of the Department of Irrigation, Cà Mau	September 28th-29th, 2020	the governmental office and a field trip in Bạc Liêu
W, and X	civil servants of the Department of Agriculture and Rural Development, Bạc Liêu	September 28th, 2020	the governmental office
Y, Z, and α	civil servants of the	September 28th,	the governmental

	Department of Environmental and Natural Resources, Bạc Liêu	2020	office
β	the Cooperative of Brine Shrimp Farming in Bạc Liêu and	October 2nd, 2020	the governmental office
The shrimp feed industry			
Hau-Ting	the chairman of a Taiwanese shrimp feed company	May 28th, 2020	Hau-Ting's office in Long An
Hùng	a sales manager from a Taiwanese shrimp feed company	June 20th and 22nd, 2020	Hùng's office in Bạc Liêu
Γ	the vice-principal of a previous Taiwanese shrimp feed company	November 20th, 2019	the company's office
δ(delta)	a sales agent of shrimp feed	June 22nd, 2020	the sales agent's shop in Bạc Liêu
ϵ (epsilon)	a sales agent of aquaculture products	June 22nd, 2020	the sales agent's shop in Bạc Liêu
Shrimp hatcheries			
Huỳnh	a technician in Dr Anh's hatchery	May 21st, 2020	Dr Anh's hatchery in Ninh Thuận
Ching-Shin	a hatchery owner (Chinese Malaysian)	May 22nd, 2020	the hatchery in Ninh Thuận
ζ(zeta)	a hatchery technician	June 22nd, 2020	the hatchery in Bạc Liêu
η(eta)	a governmental hatchery, Cà Mau	August 21st, 2020	the hatchery in Cà Mau
θ(theta)	a governmental hatchery, Bạc Liêu	September 30th, 2020	the hatchery in Bạc Liêu
Shrimp buyer			
Linh	a shrimp buyer, Bạc Liêu	June 23rd, 2020	Linh's office in Bạc Liêu

Source: Author

Figure 5 Talking to Vietnamese female workers while waiting for shrimp harvesting
Source: Author, taken by a Taiwanese photographer

3.2.3 News, reports, magazines, documents, and online resources

During the research, I collected news, reports, and government documents to explore the history of shrimp domestication and shrimp farming and the development of governmental policy in the Mekong delta. To review the history of shrimp domestication and shrimp farming, I collected news from Shrimp News International company websites (1988-2021) and aquaculture magazines, like Tập chí Thủy Sản Vietnam and Tập chí Con Tôm (2020-2021). These aquaculture magazines are showcases of industrial development. Other online resources, such as Vietnamese and Taiwanese shrimp company websites and Facebook fan pages, are also useful resources to know the newest industrial information. As for the development of governmental policy, I reviewed newspapers from local government websites (2010-2021) and documents released by the Vietnamese government. This policy review helped me understand the evolution of land-use planning and rice-shrimp farming practices.

3.2.4 Research ethics

The research followed ethical principles for social science research as outlined in the

Economic and Social Research Council (ESRC) Framework on Research Ethics, and the code of ethics of relevant professional bodies, like the Association of Social Anthropologists. This research proceeded only after ethics approvals from Durham University.

I considered five ethical issues in my research: informed consent, privacy, harm, exploitation, and consequences for future research (Atkinson and Hammersley, 2008). First, when seeking consent from potential participants, I presented them with a written statement explaining the purpose of my research, my role in the field, potential uses of the results, and how data will be collected and stored. Informants were provided informed consent with full knowledge of my research. I obtained their consent to ensure they were willing to share their stories and opinions. Second, while doing ethnography and taking field notes, I was aware of the boundaries of public and private life of my informants to judge whether it is proper or not to take certain information in my fieldnote. Third, I avoided any potential harm to my informants from participating in this research, like anonymising informants' and villages' names in my written materials and publications. Under the authoritarian context in Vietnam, even after researchers return home from the field, they are still self-disciplined and decide what to write or omit in their publications to protect informants (Menga, 2020). Fourth, in terms of exploitation, I thought about how my research can contribute to participants' lives because my informants might expect me to improve their living conditions or other forms of return. Fifth, I considered maintaining my relationships with my informants after finishing my PhD project and other future research projects. Moreover, I followed the UK's relevant legislation, known as General Data Protection Regulation (GDPR), to ensure sensitive and personal data are stored properly. Materials are stored in a password-protected file on my computer and secure online document storage.

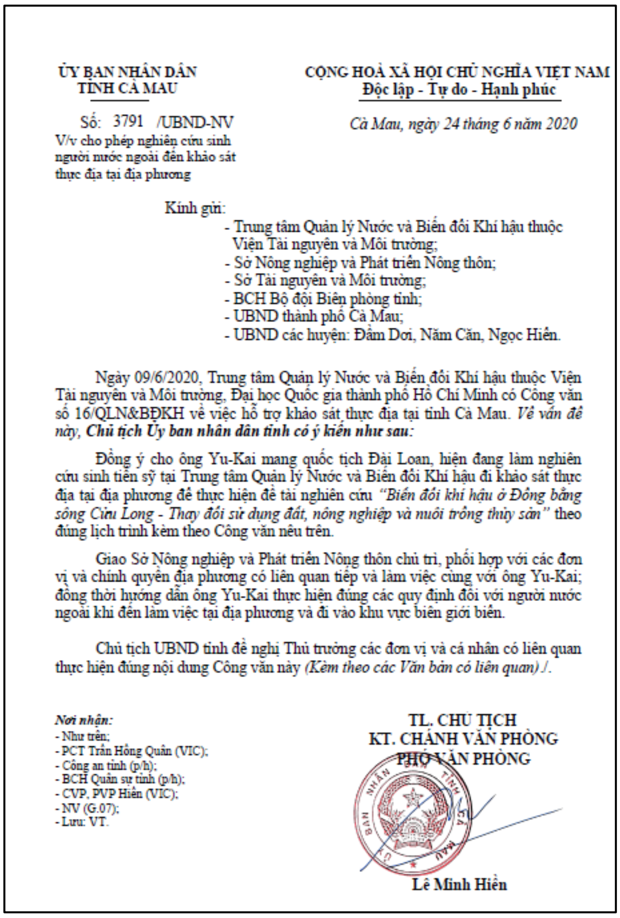
3.3 Negotiating an authoritarian state

The experience of designing and conducting fieldwork has been influenced by Vietnam's political authoritarianism. Scholars have been discussing the art of doing research in Vietnam in the context of authoritarianism for around 15 years (Scott et al., 2006; Gillen, 2012, 2016; Turner, 2014; Menga, 2020). This research provides the experience of a male Taiwanese PhD candidate conducting fieldwork from September 2019 to October 2020 (during the pandemic of COVID-19) in the Mekong Delta.

Generally, there are three key aspects of doing fieldwork in an authoritarian country. First, before and during the fieldwork in Vietnam, foreign researchers must obtain research visas and research permits from central and local governments. Second, during the field trip, foreign researchers must decide which research assistant(s) they will work with since the positionality of the research assistant also shapes the fieldwork. Due to the language barrier, foreign researchers must decide whether to work with a research assistant or translator. Different working models shape informants' feelings and reactions and the data collection. Third, researchers' identity (age, gender, and nationality) influences how they will be perceived by research subjects. By reflecting on their positionality, researchers can map out the socio-political distance between researcher and researched within the power structure (Rose, 1997). In short, it is worth learning how to conduct ethnographic work within authoritarian countries rather than assuming it as impossible since doing fieldwork in democratic regimes is a particular historical condition (Michaud, 2010).

3.3.1 Collecting red stamps: research permits from local governments

Vietnam has strict regulations on foreign researchers interviewing civil servants and conducting fieldwork in the countryside. To meet governmental requirements, researchers must obtain a research visa and collect red stamps, which refer to the official seal and denotes research permits from local governments (Figure 6) (Turner, 2014). As a newcomer to Vietnamese studies, it was difficult to figure out the application process for a research visa and research permit since the Vietnamese government does not have standard guidelines. During the first week in Vietnam, I visited the Education Division, Taipei Economy and Culture Office Hồ Chí Minh in City. The Taiwanese Secretary-General warned me that Vietnam is an authoritarian country and suggested I not do research in Vietnam. Furthermore, she told me that even playing a song in a public space might be censored by the government. This conversation made me more nervous, and I started to be self-disciplined. However, after conducting the fieldwork for 12 months, I realised that state surveillance is not omnipotent but looser in reality.



ỦY BAN NHÂN DÂN
TỈNH CÀ MAU

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Số: 3791 /UBND-NV
V/v cho phép nghiên cứu sinh người nước ngoài đến khảo sát thực địa tại địa phương

Cà Mau, ngày 24 tháng 6 năm 2020

Kính gửi:
- Trung tâm Quản lý Nước và Biến đổi Khí hậu thuộc Viện Tài nguyên và Môi trường;
- Sở Nông nghiệp và Phát triển Nông thôn;
- Sở Tài nguyên và Môi trường;
- BCH Bộ đội Biên phòng tỉnh;
- UBND thành phố Cà Mau;
- UBND các huyện: Đầm Dơi, Năm Căn, Ngọc Hiển.

Ngày 09/6/2020, Trung tâm Quản lý Nước và Biến đổi Khí hậu thuộc Viện Tài nguyên và Môi trường, Đại học Quốc gia thành phố Hồ Chí Minh có Công văn số 16/QLN&BĐKH về việc hỗ trợ khảo sát thực địa tại tỉnh Cà Mau. *Về vấn đề này,* ***Chủ tịch Ủy ban nhân dân tỉnh có ý kiến như sau:***

Đồng ý cho ông Yu-Kai mang quốc tịch Đài Loan, hiện đang làm nghiên cứu sinh tiến sỹ tại Trung tâm Quản lý Nước và Biến đổi Khí hậu đi khảo sát thực địa tại địa phương để thực hiện đề tài nghiên cứu *"Biến đổi khí hậu ở Đồng bằng sông Cửu Long - Thay đổi sử dụng đất, nông nghiệp và nuôi trồng thủy sản"* theo đúng lịch trình kèm theo Công văn nêu trên.

Giao Sở Nông nghiệp và Phát triển Nông thôn chủ trì, phối hợp với các đơn vị và chính quyền địa phương có liên quan tiếp và làm việc cùng với ông Yu-Kai; đồng thời hướng dẫn ông Yu-Kai thực hiện đúng các quy định đối với người nước ngoài khi đến làm việc tại địa phương và đi vào khu vực biên giới biển.

Chủ tịch UBND tỉnh đề nghị Thủ trưởng các đơn vị và cá nhân có liên quan thực hiện đúng nội dung Công văn này *(Kèm theo các Văn bản có liên quan)*./.

Nơi nhận:
- Như trên;
- PCT Trần Hồng Quân (VIC);
- Công an tỉnh (p/h);
- BCH Quân sự tỉnh (p/h);
- CVP, PVP Hiền (VIC);
- NV (G.07);
- Lưu: VT.

TL. CHỦ TỊCH
KT. CHÁNH VĂN PHÒNG
PHÓ VĂN PHÒNG

Lê Minh Hiền

Figure 6 Research permit from the Cà Mau government
Source: Author

Finding a host research institute is the first step for foreign researchers to apply for research permits. In the first three months (September-November 2019), I held a student visa for Vietnamese courses at the University of Social Sciences and Humanities, Vietnam National University Hồ Chí Minh City. I visited three scholars in Southern Vietnam. Some scholars argued that I could receive research permits with a student visa; others suggested that I must obtain a research visa while conducting fieldwork. According to the Vietnamese government, the student visa and the research visa are in the same category: Du Học (DH) (Bộ ngoại giao Việt Nam, 2014). DH refers to a type of visa for people studying or doing intership in an educational institute. During that time, an international NGO helped me apply for a research permit with my student visa for the Vietnamese language course, and I was granted a research permit by the Cà Mau government. Thus, governmental regulation and surveillance exist but do not operate as strictly as we might understand or imagine.

Collecting red stamps needs to go through from the central to local governments, but local governments do not work to the same review procedure, which shows chinks within the state machine. From February to October 2020, I was affiliated with the Centre of Water Management and Climate Change (WACC) at Vietnam National University - Hồ Chí Minh City (VNU – HCM) to obtain a research visa and research permits. My application for a research visa was approved by the Ministry of Public Security. Applying for research permits in the field required submitting the abstract of my research project and my fieldwork schedule. However, local governments have different review procedures. In my fieldwork, I applied for research permits from the Cà Mau government and the Bạc Liêu government. I usually submitted research applications three weeks before field trips for the review of local governments. Only the Bạc Liêu government asked me to provide research questions in advance. Even after my application was approved, and my interviewees were informed by the Bạc Liêu government, WACC and I did not receive the research permit, and I had to visit and ask the Bạc Liêu government to provide a copy of the research permit. The Cà Mau government is familiar with the research permission because many foreign researchers conduct their research in Cà Mau peninsula, a restricted military area. The Cà Mau government always quickly replied to my application and assigned a civil servant, Sơn, as a research assistant to follow and help me during the field trip. By contrast, the Bạc Liêu government never assigned a research assistant for me.

After receiving research permits and entering the field, foreign researchers manage their relationships with civil servants and even police officers, representing state power. According to research permits, all schedules must follow what was stated on the application. Police officers did not follow me during the field trip but punctually appeared in the field sites when I visited restricted areas. After the field trips, the civil servant wrote a report about my work in the field to the local governments. In my experience, my research project in the Mekong Delta was never interrupted by a civil servant or police officer. Instead, Sơn, the civil servant, helped me communicate with local police officers. For instance, police officers never contacted me directly but called Sơn to follow up on my schedule. Sơn is from Cà Mau and is older than police officers, so police officers usually respect him. In another case, I visited Trúc, a farmer who is my Vietnamese teacher's relative. The farmer and Sơn had graduated from the same high school. Thus, Sơn told the police officer on his mobile phone that it was a family visit, so no police officer visited Trúc's house. Sơn knows that his appearance and work are a part of national surveillance but tries to open more free space for me. Researchers are less regulated by local governments in the Mekong Delta than in the uplands or the broader region near China and Laos (cf. Luong, 2006; Bonnin, 2010; Turner, 2014).

Even though some lowland regions in Southern Vietnam are strict, I was allowed to stay overnight in the village during the field trips (cf. Luong, 2006).

The appearance of the civil servant and police officers would affect informants' answers. The obvious question is how to evaluate data collection in this circumstance. In my field trips, it depended on the type of questions and the relationship among informants, civil servants, and police officers. My questions were generally about environmental management and farming practices. Farmers described their practice methods. If farmers are already aquatinted with the civil servant, they looked more comfortable during the interview. Even without civil servants and police officers on some occasions, informants seldom tell me any other different narratives around shrimp farming. However, not all research activities are monitored by the state. For example, researching private sectors, such as companies or laboratories, does not require research permission from local governments but does require consent from informants.

3.3.2 Selecting a research assistant

In Vietnam, foreign researchers need to decide whether to work with research assistants (or translators) either from their host institutes or recruitment from villages. Many researchers work with research assistants from their host institutes as interpreters (Scott et al., 2006; Bonnin, 2010; Turner, 2010). Although WACC has rich experience in assisting foreign postgraduate students, especially Dutch researchers, with translation, I had not recruited any interpreter from WACC. Instead, I collaborated with a civil servant, a staff member from an NGO, and local people rather than researchers from WACC. There are three reasons I adopted this plan.

First, research assistants from host institutes are usually not local people but outsiders. They might have limited experience in research sites and local communities, such as young lowland assistants visiting highland areas (Bonnin, 2010). Their positionality, like age, race, and gender, shapes how they interact with and are perceived by the researched. Since Vietnam still has a strong social hierarchy and Confucian traditions, it profoundly affects everyday conversation and social positions. The researcher-interpreter relationship might also have tensions in the field. For example, due to social pressure, female interpreters are less willing to go to rural areas (Scott et al., 2006). Interpreters have their thoughts and might disagree with the project. How interpreters speak and act also shapes informants' perceptions. Furthermore, I already had a civil servant and a car driver in my team, and police officers came along. Having another research assistant might have been five people in an informant's house and became pressure on informants.

Second, even though I did not work with translators, I still teamed up with the civil servant, the NGO staff member, and a Vietnamese driver and received Vietnamese language training. They are all from the Mekong Delta and have a strong network with farmers and other governmental institutes. Working with them helped me get into field sites more easily. Nevertheless, this fieldwork collaboration is also a business between researchers and assistants. The Mekong Delta is a research hotspot for Vietnamese and foreign researchers, circumstances which have created a research assistance industry. Once, a research assistant forwarded me his previous working contract with a Russian researcher. The contract price was 150 US dollars per working day, a figure that did not include other travel expenses. This daily payment is fifteen times more than the average daily salary in Hồ Chí Minh City (9.62 USD). On another occasion, I visited my civil servant friends in a governmental research institute during the afternoon teatime. I was acquainted with a senior female civil servant who teaches English online and works with foreign researchers in her spare time. After meeting me conducting fieldwork in the Mekong Delta, she was hospitable and eager to assist me and even sent her previous household survey to me. It is not surprising that foreign researchers are seen as cash cows. However, it does not mean that collaboration is merely a business. With the introduction of the international NGO, I developed a long-term collaborative relationship with a 40-year-old Vietnamese driver. The driver was also my consultant since he had many experiences driving foreign researchers and civil servants in the Mekong Delta. He knew many governmental informants, reminded me to follow local manners and customs, and offered any local knowledge about shrimp aquaculture.

Third, speaking Vietnamese helped me have more informal conversations with my informants and act in the field without any mediator. Once I collaborated with an NGO, using an NGO staff member as an interpreter, but my interpreter did not fully translate all the sentences from my informants. Therefore, I decided to speak Vietnamese and work independently to understand every sentence. I had developed my Vietnamese language skill to the fluent level (with a C1 certificate, effective operational proficiency), so I was able to conduct the interviews and ethnographic work in Vietnamese independently. Many informants were surprised that a foreigner could speak proper Vietnamese. Once I interviewed female civil servants, they told me that it was excellent that I did not rely on translators so that the interview could go well and was not time-consuming. While being in Vietnam, I studied Vietnamese for 4 hours every weekday for seven months. Before doing interviews, my Vietnamese teacher helped correct my spelling and grammar to ensure my informants understood the questions. However, working without an interpreter is a double-edged sword. I can directly ask questions and express myself with my voice and tone. Yet, my pronunciation was sometimes incorrect, so it can be hard for informants to understand. I also sometimes did not fully understand their sentences and asked them to explain the meaning. Learning and speaking Vietnamese served to displace and decentre my research assumptions and social identity to get closer to local contexts.

3.3.3 Mapping power relations between researchers and informants

My Taiwanese male positionality shapes how my informants perceived me in the field. In the previous section, I mentioned how I moblised my nationality identity to build networks with informants. However, the Taiwanese positionality did not always work out well. It was very difficult to contact Taiwanese shrimp feed companies in Vietnam. After contacting a Taiwanese shrimp feed company three times, Hau-Ting, the company chairman, finally allowed me to visit his company near Hồ Chí Minh City. At the very beginning, Hau-Ting did not trust me and asked my opinions on relations between capitalism and environmental protection. I answered that I am not an extreme environmentalist but would like to know how this industry works. After a while, Hau-Ting said that "*in the end, you must pick a side and have a perspective to explain your data, but what I worry about is that some NGOs just asked us lots of questions and criticised us or even reported that to the government*." In the end, he trusted me and introduced the Vietnamese manager and sales agents in Bạc Liêu to me.

The national identity of researchers significantly shapes fieldwork in socialist Vietnam. Many American researchers focusing on a non-war topic also faced the legacy of the Vietnam War during their field trips (Sowerwine, 2014; Gillen, 2016). For instance, they sanitised their research topic by highlighting the ethnographical and ethnobotanical aspects rather than policy analysis. My Asian positionality shows a different experience from white researchers or the concept of whiteness from the First World (Gillen, 2012, 2016). According to the Vietnamese diplomatic policy, Taiwan is a part of China, but in practice, both central and local governments and many informants discern differences between Chinese and Taiwanese. Thus, I was allowed to visit villages in the military restrict zone in Cà Mau. Furthermore, many Vietnamese women in the Mekong Delta marry Taiwanese men through the introduction of sales agents (commercial marriage). This bottom-up connection between Vietnam and Taiwan created many research opportunities for me in the Mekong Delta. For instance, while I was interviewing retail shop owners, they were very excited to tell me that her sister married a Taiwanese man and now lives in Taiwan. The interview was interrupted. She immediately called her sister via Facebook and asked me to speak to her sister in Mandarin.

Gender identity also influences researchers' accessibilities. It is common to talk about others' marriage status in Vietnam, which becomes very hostile to female researchers. If male researchers are single, Vietnamese usually suggest that one should find one's wife during the field trip. Other female single researchers, especially Asian scholars, are often questioned about why they are not married and why they do not stay with their partners. Male researchers are involved more in the masculine culture in Vietnam (Gillen, 2016). Most of my informants are male, and there was a culture of drinking in lunches and dinners after interviews. Although meals were prepared by their wives, women rarely had the meal with us. Gillen (2016) argues that drinking alcohol in the field in Vietnam is a type of malleable research ethic. Drinking alcohol is deemed as a way of building up social ties with male informants or getting further information from them. In the Vietnamese culture, informants showed their hospitability to researchers and guests by preparing meals and alcohol. However, alcohol consumption turned the field into a racialised and gendered space, where male bonding between Vietnamese informants and foreign researchers was formed. Female participants were usually excluded from this occasion. In my field trips, I only provided small subsidies or gifts for my informants for their meals and help but did not offer any alcohol consumption to reduce potential risks of alcohol misuse (cf. Gillen, 2012).

3.4 Conclusion

This chapter demonstrated the research design and methodology of this research. This research adopted multi-species and multi-sited ethnography to operationalise the notion of hydro-social life in the hatchery, the shrimp farm, and the laboratory. It developed multi-species and multi-sited ethnography by contextualising research methods for each research site. First, this research explained how the hatchery requires delta methods and laboratory ethnography to analyse the history of shrimp domestication and the operation of shrimp reproduction. The hatchery is a lab-like space for animal research propagation in the building but is constantly shaped by the deltaic environment. Second, it developed delta methods to investigate the operation of shrimp economies in the deltaic environment. The spatiality and temporality of the delta profoundly shape the practice of shrimp farming. Third, this research revisited laboratory ethnography by comparing various kinds of labs and bringing technicians and laboratory animals foreground. Knowledge production and commodity innovation for the shrimp industry are supported by the labour work of technicians and the life and death of experimental shrimps.

Furthermore, this chapter elaborated on details about data collection and overviewed ethical issues associated with the research. My ethnographic works were deployed by participatory observation, semi-structured interviews, and secondary data collection. I developed rapport with informants by mobilising my social network, connecting with a grassroots group and utilising my national identity. In addition, I considered five common ethical issues in research projects: informed consent, privacy, harm, exploitation, and consequences for future research. The last section situated my fieldwork experience under the broader literature of authoritarianism. It considered the challenge of doing fieldwork in an authoritarian state and how issues of positionality influenced access, data quality, and movement in the field.

Chapter 4 Unpacking the Life Cycle of Shrimp: Shrimp Domestication and Industrial Production

This chapter focuses on how the hatchery facilitates the formation of shrimp economies by domesticating shrimp, industrialising shrimp reproduction, and developing supporting industries. The hatchery conducts research and experiments on shrimp domestication. Domestication is a set of techno-scientific practices and multi-species relations (cf. Lien, 2015: 122). In shrimp domestication, shrimp become “accustomed to the household” (Cassidy and Mullin, 2007: 5) and are“*bred in captivity for purposes of economic profit to a human community that maintains complete mastery over its breeding organization of territory and food supply*” (Clutton-Brock, 1989: 7). Shrimp domestication unpacks the life cycle of shrimp, mimics their living environment, artificially proliferates larvae, and produces artificial feed to align their life cycle with the rhythms of nature and capital. Domestication shows not only an asymmetrical relationship that the power of human dominates the life of other but also a coevolutionary and symbiotic relationship that humans align their everyday life with the life cycle of domesticated animals and plants, such as algae and brine shrimp. Practices of shrimp domestication capture and breed shrimp in an enclosed architecture with husbandry skills, and enrol algae and brine shrimp as food, and bacteria and viruses as pathogens into the circuits of capital (also see Leach, 2007: 72).

The hatchery industrialises shrimp reproduction and ecological conditions of production on a commercial scale. As Lien (2015: 110) explains, in the context of salmon, the hatchery is “*a site and a moment where specific life-forms (very young salmon) emerge together with particular forms of life (industrial labor practices) through carefully choreographed alignments of … water and eggs*.” Vietnamese shrimp hatcheries entangle the life cycle of shrimp, algae, and brine shrimp (life forms) with industrial labour practices (forms of life) to create distinctive forms of hydro-social life. The industrial mode of production makes shrimp economies scalable by managing water-shrimp-human-environment relations. Yet, shrimp hatcheries are constantly threatened by viruses and bacteria. Thus, biosecurity is vital for securing the life of shrimp and the profit of the hatchery.

This chapter analyses shrimp economies in hatcheries through the history of shrimp domestication, the industrialisation of shrimp reproduction, and the development of supporting industries for shrimp aquaculture. Section 4.1 reviews the history of shrimp domestication to describe the birth of shrimp aquaculture. Section 4.2 focuses on the artificial propagation of shrimp and the distinctive hydro-social life for nurturing broodstocks and propagating larvae in hatcheries. Section 4.3 analyses the development of supporting industries, especially algae, brine shrimp, and shrimp feed production, for the production and reproduction of shrimp. Each industry plays a crucial role in connecting species, building a food chain, and propping up shrimp economies. I adopted a firm-centric approach to data gathering in relation to hatcheries, interviewing a farmer-led brine shrimp enterprise, a governmental brine shrimp cooperative, and shrimp feed companies. I also visited hatcheries, brine shrimp farms, and a shrimp feed factory to pay attention to the texture of scalability in hydro-social lives (cf. Lien, 2015: 106).

4.1 Domesticating shrimp: the rise of shrimp aquaculture

The history of shrimp domestication is simultaneously a story of globalisation as shrimp domestication originates from diverse localities, such as Japan, Taiwan, America, Ecuador, and Thailand. There is no single origin; shrimp domestication in one place is influenced by knowledge production and technology of shrimp farming in other places. Generally, the development of shrimp domestication can be divided into three stages:

(1) unpacking the life cycle of shrimp from the 1930s to the 1960s, (2) constructing the shrimp hatcheries, producing artificial shrimp feed, and designing shrimp ponds from the 1960s to the 1970s, and (3) innovating Specific-pathogen-free (SPF) shrimp from the 1990s. Although shrimp domestication is mostly dominated by scientists, it is significantly influenced by governments, foreign agencies, and companies. Histories of shrimp domestication are articulated in different geographical, historical, and political contexts.

4.1.1 From wild to domesticated: unpacking the life cycle of shrimp

In shrimp domestication, humans first unpacked the life cycle of shrimp to understand its reproductive biology, growing cycle, and the process of metamorphosis. From the 1930s, scientists started to understand the life cycle of shrimp to develop shrimp aquaculture in the context of the modernisation science. In Japan in 1934, Kuruma shrimp were the first shrimp species domesticated by Dr Motosaku Fujinaga, the father of shrimp farming. Shrimp domestication in Japan was interrupted by World War II and relaunched in the 1950s.

Japanese shrimp farming technology transferred to Taiwan with the support of national and international institutes in the context of Malthusian concerns. Dr Fujinaga's research profoundly influenced Japanese and Taiwanese research. Dr I-Chiu Liao, a Taiwanese scientist and the father of black tiger shrimp farming, studied for his doctoral degree in Japan and held a postdoctoral fellowship in Dr Fujinaga's laboratory. With this experience, in Taiwan in 1968, Dr Liao transferred the technique of domesticating Kuruma shrimp to Taiwan and domesticated black tiger shrimp. In addition, the Rockefeller Foundation and the Joint Commission on Rural Reconstruction (JCRR), a Taiwanese governmental institute, facilitated the development of shrimp farming in Taiwan. The Rockefeller Foundation believed in a looming Malthusian catastrophe and aimed to solve the food crisis in Asia. The Rockefeller Foundation cooperated with the JCRR, especially on the production of protein foods. In an interview in 1968, Dr Liao said that "*it will be wonderful if aquaculture can be as productive as animal husbandry*" (Lu, 2018). During 1966-1973, the Rockefeller Foundation funded around 475,000 dollars on personnel expenses for researchers and laboratory equipment to the Taiwanese government to develop aquaculture (Hsuch, 2013). Meanwhile, many Taiwanese scientists and technicians were supported by the JCRR. They studied or visited Japan to learn and introduce the breeding technique. This technology transfer provided the basis for aquaculture studies in Taiwan.

In parallel, the United States developed its independent shrimp farming programme in the context of marine and coastal resource management. In 1958, the American shrimp farming programme was funded by the Gulf States Marine Fisheries Commission (GSMFC) and conducted by Galveston Lab in Texas, US (Rosenberry, 1998). The GSMFC proposed that Galveston Lab could apply their techniques of culturing marine phytoplankton, developed from the red tide investigation in the Gulf, to shrimp breeding. Scientists learned how to identify shrimp larvae from plankton samples. In the 1960s, American scientists reared five shrimp species in laboratory conditions, from 100-millilitre beakers via an 80-litre system and 18-litre carboys to a 555-litre polyethene tank (Rosenberry, 1998).[6] These techniques were later exported to other countries and developed beyond the original concern of marine and coastal resource management.

[6] These five shrimp species are brown shrimp (*Penaeus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), the Atlantic seabob (*Xiphopenaeus kroyeri*), the white shrimp (*Penaeus setiferus*), and *Trachysalambria curvirostris*.

The process of unpacking the life cycle of shrimp was full of surprises. In 1970, Dr Shao-Wun Lin, a Taiwanese scientist working at the Food and Agriculture Organization of the United Nations (FAO), imported 300 giant freshwater shrimp from Thailand to Taiwan and cooperated with Dr Liao for their artificial propagation. While Dr Lin was in Penang, Malaysia, he conducted the artificial propagation experiment of giant freshwater shrimp, harvested larvae from rivers, and fed them with different foods, but every experiment group eventually failed. One day Dr Lin's wife cooked a beef soup, and Dr Lin spontaneously fed larvae with the beef soup. After a few days, only the group of larvae having the beef soup survived. Dr Lin realised that the key point is not about shrimp feed but water salinity since larvae cannot survive in pure freshwater but need some salinity. Dr Lin also observed that female broodstocks only lay eggs at the estuary where freshwater and saline water meet (Tsai and Yang, 2020).

The innovation of artificial propagation capitalised and industrialised the life cycle of shrimp. The hatchery can collect broodstocks from the sea and reproduce larvae in well-controlled conditions. Farmers do not need to collect wild larvae in the sea but now purchase artificially propagated larvae from hatcheries. The technique of artificial propagation brings three benefits to shrimp farming. First, it is easier to control the survival rate of larvae from hatcheries. The growth rate and size of larvae can be aligned to avoid cannibalism between bigger and smaller shrimp. Farmers can put the same size of shrimp in the same pond. Second, with the alignment of growth rate, farmers and capitalists can speed up turnover time with capital needs. Third, it can maximise the value capture in shrimp harvesting.

4.1.2 Commercialising shrimp production

After unpacking the life cycle of shrimp, scientists mimicked its life cycle and bred them in lab-like hatcheries and shrimp ponds to reach a commercial scale. Although

Kuruma shrimp were domesticated in the 1930s, they were commercially produced through a semi-intensive culture method in 1963 because of the development of larval rearing, the artificial diet, and the introduction of round pond (Rosenberry, 2001). In 1963, Dr Fujinaga retired from the Research Bureau of the Japanese Fisheries Agency and established a shrimp farm with his colleagues to develop a model for rearing shrimp larvae outdoors. In addition, during the 1960s, the rapid development of shrimp farming in Japan was facilitated by the Income Doubling Plan, which aimed to boost the development of scientific research. To achieve the goal of modern shrimp farming, shrimp domestication and the development of the shrimp industry relied on not only the technique of artificial propagation but also caring techniques, such as the production of algae and plankton, the construction of shrimp hatchery, and the design of shrimp pond (cf. Hsueh, 2010).

The cultivation of algae and plankton is the key to breeding shrimp from larvae to postlarvae. In Taiwan in 1968, while Dr Liao first propagated the larvae of black tiger shrimp, shrimp mostly died because he did not know what kind of food to provide to larvae in the mysis stage. The problem was solved after Ting-Lang Huang, a technician at the JCRR, learned the technique of cultivating algae from Japan and introduced it to Taiwan. In the western hemisphere, plankton was massively produced through a unique cultivating technique innovated by Galveston Hatchery in America. From 1952 to 1962, this research lab was assigned by the Department of Interior's Bureau of Commercial Fisheries to investigate the red tides in the ocean. The investigation result contributed to the techniques of culturing marine phytoplankton. These techniques of algae and plankton cultivation were the key nutrients for shrimp larvae in hatcheries.

In the 1960s, scientists practised the algae cultivating technique through two kinds of hatchery system to scale up production: the Japanese system (green water) and the

Galveston system (clear water) (Rengarajan, 1996; Rosenberry, 1998). The Japanese system is also known as the Taiwanese system, community culture system, and fertilised system. In the Japanese system, shrimp, algae, and plankton are raised in the same tank from spawning, hatching, larval and postlarval rearing. The advantage of this system is the low maintenance cost, and the breeding process is all in the same tank. It aims to create a balanced community in tanks. However, it is hard to control the plankton population with other species and might have undesirable species in the tank. The Galveston system (or unfertilised system) massively produces larvae, algae, and brine shrimp in different containers. Algae, plankton, and brine shrimp are added to the larvae's tank. The Galveston system can maintain water quality, manage food provision, and practise biosecurity practices better than the Japanese model. The Galveston system first dominated in the western hemisphere and is currently widely adopted with modification in hatcheries worldwide, such as Honduras, Panama, Brazil, and Ecuador, since it is biosecure and has a lower risk of shrimp disease. The Galveston system is different from the Japanese system. In 1971, the United States and Japan started a cooperative program in shrimp culture facilities. Although Japanese scientists visited Galveston Lab, they did not visit and discuss the Galveston Method since they already had the Japanese system for hatcheries. During that period, Japanese scientists were more interested in East Matagorda Bay in Texas as a potential site for shrimp farms to scale up shrimp production.

A shrimp pond is a kind of domus and an active technology that encloses animals to control their breeding (cf. Leach, 2007: 107). The design of shrimp ponds brought shrimp farming from mixed culture and extensive farming to monoculture and intensive shrimp farming, which capitalises ecological conditions of shrimp production (cf. Banoub et al., 2020). Due to the cold climate, Japanese scientists had to transplant their technology to warmer places for higher productivity. In 1964, Japanese scientists deployed the green water technique and double-bottomed round tanks in West Bay in Panama City, Florida. The round pond design of the Japanese model is more efficient, productive, and intensive than the conventional shrimp pond because of its water exchange system, sludge draining, and aerobic sand bed filter (Rosenberry, 2001). However, daily exchanging water leads to a higher cost of rearing plankton in the shrimp pond. The Japanese method and design for Kuruma shrimp were transferred to other locations and applied to other species, such as black tiger shrimp in Taiwan and whiteleg shrimp in the United States. This phase is generally known as a 'second wave' of shrimp aquaculture development. In the 1980s, with the development of intensive shrimp ponds, shrimp farming was rapidly developed but seriously hit by a shrimp disease, White Spot Syndrome Virus (WSSV). Simultaneously, salmon aquaculture was strongly impacted by a new disease, the Immuno Salmon Anemia virus, in Norway, Canada, and Chile (Bustos-Gallardo and Irarrazaval, 2016). The outbreak of shrimp disease directed the development of shrimp domestication toward the innovation of SPF shrimp.

4.1.3 The birth and spread of SPF larvae

The innovation of SPF whiteleg shrimp was a response to the spread of shrimp disease from intensive farming. The concept of SPF shrimp was borrowed from the idea of clean laboratory animals, like mice, for medical research in the 1940s and the poultry industries, such as SPF pigs. In the early 1990s, SPF whiteleg shrimp were first bred by Dr Jim Wyban in the Oceanic Institute (OI) of Hawaii Pacific University. Hawaii was the ideal place to breed SPF shrimp due to the climate, geographical isolation, and better seawater quality. The SPF shrimp programme was funded by the US Department of Agriculture to develop the US Shrimp Farming Consortium. To breed SPF shrimp, Dr Wyban recruited international scholars as their technical advisory group. The advisory group included Dr Kuni Shigueno from Japan, Dr I-Chui Liao from Taiwan, and Dr Trygve Gjedrem from Norway. Dr Gjedrem (the father of Atlantic Salmon breeding) recommended that Dr Wyban adopt the technique of genetic selection and family-based breeding to enhance the trait of disease resistance. Dr Wyban applied genetic technology to select traits of faster growth rate and better disease resistance (Chamberlain, 2010). As a result, the growth is faster, the length of production is shorter, and the feeding costs are lower. The innovation of SPF shrimp is the strategy of species-switching for speeding up the rate of biomass accumulation and enhancing disease resistance capacity (Banoub et al., 2020). The achievement of SPF shrimp was supported by concepts from medical research and the poultry and salmon industries, funding from the American government, and breeding techniques from international scholars.

SPF shrimp later expanded from Hawaii to other countries and significantly shaped the global shrimp market. It failed in Latin America but has been widely exported to Asian countries. In the late 1990s, SPF larvae were first exported to Ecuador but did not work out since the SPF stock was vulnerable to a new virus, Taura Syndrome. Consequently, this failure tarnished the reputation of SPF shrimp in Central America. Instead, SPF shrimp has been very popular and widely sold in the Asian market, such as Taiwan, Thailand, Indonesia, and Vietnam, because of the outbreak of WSSV. Furthermore, CP Thailand company later established its family of SPF shrimp broodstock and became one of the major producers of SPF shrimp in the world. Although Thailand is not as geographically isolated as Hawaii, CP Thailand still invested huge capital in creating an inland island facility to prevent pollutant resource invasion (Loomis, 2017). Subsequently, whiteleg shrimp became the dominant species farmed in the global shrimp market.

Although SPF whiteleg shrimp succeed in the global shrimp market, scientists and companies have been developing other kinds of SPF shrimp. In 1992, Dr Wyban left OI and established High Health Aquaculture company with his wife to commercialise SPF shrimp. Dr Wyban bred SPF stocks of whiteleg shrimp, Kuruma shrimp, black tiger shrimp, and blue shrimp. Compared to whiteleg shrimp, he argued that none of the other shrimp has good production traits. These species are tasty but grow slower, are susceptible to mortalities, or have inferior inherent production traits compared to whiteleg shrimp (Rosenberry, 2015).

In order to explore the current development of SPF shrimp, in 2020, I interviewed two Taiwanese scientists working on different species of SPF shrimp. I also visited their labs and hatcheries to learn about the breeding process. Professor Mei-Yu is a distinguished biologist currently developing SPF black tiger shrimp. She believes that although black tiger shrimp grows slowly, SPF black tiger shrimp can still have a market niche as a large size of shrimp. In 2011, Professor Mei-Yu launched the SPF black tiger shrimp breeding programme to revitalise black tiger shrimp farming in Taiwan and export them to other countries. However, shrimp farming is a declining industry in Taiwan, and Taiwanese scientists mainly focus on molecular biology rather than aquaculture research. To learn the hatching and rearing technique, Prof. Mei-Yu sent her research team to a hatchery owned by a Taiwanese company in Central Vietnam through Academy-Industry Cooperation. To build their family lineage, Prof. Mei-Yu collaborated with a French company and obtained their wild broodstocks from Madagascar, where shrimp are not yet infected. In 2020, Prof. Mei-Yu and her research team already bred four SPF black tiger shrimps.

Scientists are working on SPF blue shrimp breeding programme with Golden Corporation in Brunei. Golden Corporation is operated by Brunei royalty and a Taiwanese capitalist. Currently, the company is confronting the problem of close breeding and a narrow gene pool. To solve this problem, Golden Corporation collaborates with Agricultural Technology Research Institute (ATRI) in Taiwan. In 2020, I visited Dr Wen-Hua, the SPF blue shrimp project manager in ATRI's hatchery in Hualien, Taiwan. Dr Wen-Hua has studied and bred ornamental fish for a very long time, so he has a worldwide network with animal exporters. He planned to import blue shrimp from Mexico to enlarge the gene pool and build up the family lineage of SPF blue shrimp by mapping genetic markers and interbreeding shrimp. Even though not all kinds of shrimp are bred as specific-pathogen-free, hatcheries still breed them from wild broodstocks.

Histories of shrimp domestication show that the formation of shrimp aquaculture originated and assembled from multiple places with various geographical and historical contexts. This section divided shrimp domestication into three stages. First, from the 1930s to the 1960s, Japanese, Taiwanese and American scientists analysed the life cycle of shrimp to develop the techniques of artificial propagation in the background, like science modernisation, Malthusian concerns, and marine and coastal resource management. From the 1960s to the 1970s, scientists commercialise shrimp production through the production of algae and plankton, the construction of shrimp hatcheries, and the design of shrimp ponds. In the 1990s, American scientists developed the SPF shrimp and exported it from Hawaii to other countries to tackle shrimp disease and shape the global shrimp market. Shrimp domestication constructed water-shrimp-human-environment relations by developing a set of techno-scientific practices and multi-species relations in the hatchery on a commercial scale.

4.2 Putting the hatchery into (and beyond) the Mekong Delta

Once domesticated, shrimp are industrially produced in hatcheries. The hatchery was introduced into Northern Vietnam in the 1970s, Central Vietnam in 1984, and Southern Vietnam in 1988 (Shrimp News International, 2015). In Vietnam, the hatchery industrially propagates three kinds of shrimp species: whiteleg shrimp, black tiger shrimp, and giant freshwater shrimp. Raising these three types of shrimp species requires water quality management, care for broodstocks, and the artificial propagation of larvae but each with different water-shrimp-human-environment relations.

This section explores how hydro-social lives operate in the hatchery from three aspects. First, it analyses the geography of shrimp hatcheries on the regional scale, since hatcheries do not operate on their own but are embedded in the broader natural and social environment. The natural environment and geographical location, such as the riverine Mekong Delta and the arid climate in Ninh Thuận, present obstacles but also opportunities for different kinds of shrimp and shrimp hatcheries. Second, this section focuses on breeding and caring practices for broodstocks within hatcheries. Hatcheries construct and sustain water-shrimp-human-environment relations by managing water, mimicking the living environment, nurturing broodstocks and creating a mating atmosphere. Third, it explores the intensive care for larvae and animal trafficking from the hatchery to the shrimp farm. Before animal trafficking, water-shrimp-human-environment relations are reconfigured in order to fit with the condition of shrimp farms in the Mekong Delta.

4.2.1 Hatchery geographies in the Mekong Delta and Ninh Thuận, Central Vietnam

Hatchery geographies are shaped by living conditions, the source of broodstocks, and social organisations. The three kinds of shrimp show different forms of hydro-social life in the Mekong Delta and Ninh Thuận (Table 6).

First, marine shrimp and freshwater shrimp require different living conditions, especially water salinity. The broodstocks and larvae of whiteleg shrimp and black tiger shrimp require higher salinity (28-34‰) and that of freshwater shrimp live in lower salinity (around 12‰). Nurturing broodstocks and shrimp larvae of whiteleg shrimp and black tiger shrimp requires higher water salinity than breeding shrimp on the shrimp farm (around 17‰). It shapes the location of shrimp hatcheries because they need to find a place that can steadily supply the right water quality. In Vietnam, hatcheries are mainly located in the Mekong Delta and Ninh Thuận (Figure 7). Water quality in Ninh Thuận is better than in the Mekong Delta since there are no large rivers carrying sediments into the sea. The seawater in Ninh Thuận contains high mineral load and fewer sediments; the seawater in the Mekong Delta carries many sediments, waste, pathogens, and other chemical materials from the river upstream. Due to rivers meeting the sea, water salinity in the Mekong Delta is lower than Ninh Thuận, which is a risk for the hatchery. Furthermore, the climate in Ninh Thuận is more stable than in the Mekong Delta so that broodstocks would not be affected by the change of climate. It rarely rains in Ninh Thuận, but there are dry and rainy seasons in the Mekong Delta. Thus, hatcheries in Ninh Thuận do not worry that the rainfall affects water salinity (Figure 8).

Table 6 Geographies of shrimp hatcheries

	Whiteleg shrimp	**Black tiger shrimp**	**Giant freshwater shrimp**
Living conditions	Water salinity: 28-34‰ Temperature: 28-30°C	Water salinity: 28-34‰ Temperature: 28-30°C	Water salinity: around 12‰ Temperature: 25-30°C
The source of broodstocks	SPF broodstocks are imported from Hawaii and Thailand	Broodstocks are caught in the ocean and bought from fishers in Cà Mau	Broodstocks are bred in An Giang, the upper Mekong Delta
Social organisation	Family hatcheries Shrimp feed company hatcheries	Family hatcheries Foreign companies in Ninh Thuận	Family hatcheries Governmental hatcheries
Hatchery location	The Mekong Delta: - Closer to shrimp farms Ninh Thuận: - Better water quality - A stable and dry climate - Better location to markets in the Southern and Northern Vietnam	The Mekong Delta: - Near to the fish market to purchase broodstocks - Closer to shrimp farms Ninh Thuận: - Better water quality - A stable and dry climate - Better location to markets in the Southern and Northern Vietnam	The Mekong Delta: - Closer to broodstocks in An Giang - Closer to shrimp farms - The availability of freshwater

Source: Author

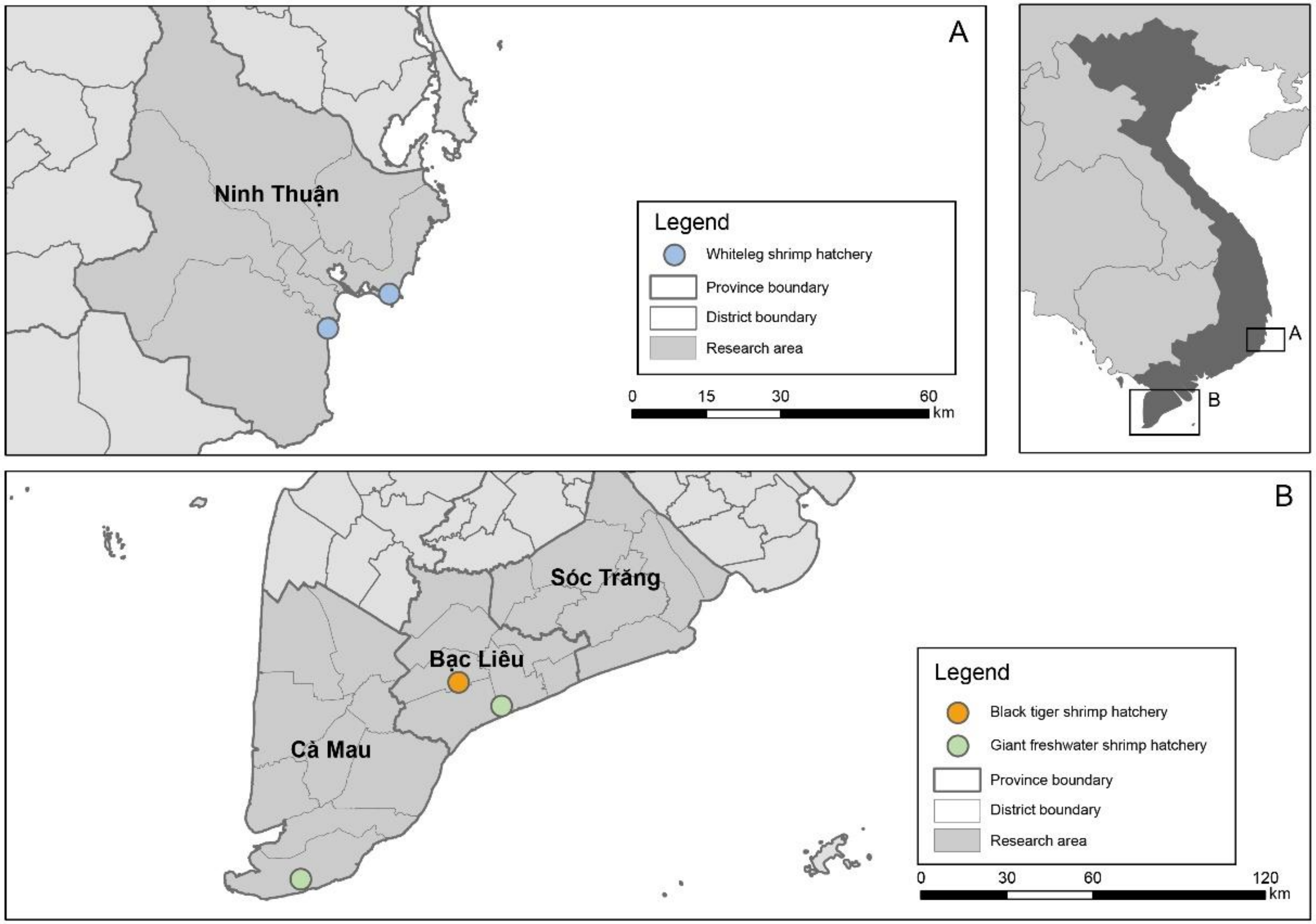


Figure 7 The location of researched hatcheries

Source: Author

Figure 8 The arid landscape of Ninh Thuận

Source: Author

Geographies of shrimp hatcheries are also affected by the source of broodstocks. Whiteleg shrimp are widely bred in the Mekong Delta and Ninh Thuận. Broodstocks of SPF whiteleg shrimp are mainly supplied by American and Thai companies. Hatcheries usually import broodstocks of whiteleg shrimp from these countries. By contrast, although the domestication of black tiger shrimp took place earlier than that of whiteleg shrimp, only a few foreign companies have developed SPF black tiger shrimp. Most of the broodstocks of black tiger shrimp are caught in the sea near the Mekong River. The larvae of black tiger shrimp are mainly reproduced in the Mekong Delta. Only Moana Technologies produces the SPF larvae of black tiger shrimp in Ninh Thuận. As for giant freshwater shrimp, its broodstocks are domestically bred in the freshwater environment in An Giang, the upper Mekong Delta, rather than in coastal provinces with saline water. The broodstock of giant freshwater shrimp requires lower water salinity, so hatcheries are mostly in the Mekong Delta rather than Ninh Thuận. Furthermore, the larvae of giant freshwater shrimp are locally sold to farmers in the Mekong Delta.

Hatcheries in the Mekong Delta and Ninh Thuận are operated by different social organisations, which influence the quality of shrimp. Generally, it is family businesses, foreign (shrimp feed) companies, and governmental institutes that invest in shrimp hatcheries. Most hatcheries in the Mekong Delta and Ninh Thuận are operated by local Vietnamese merchants as a family business. These family hatcheries have diverse breeding skills but might not produce the best quality shrimp larvae. In April 2020, the Vietnamese government released a document expressing a concern about the quality of postlarvae from local hatcheries (TỔNG CỤC THỦY SẢN, 2020). They worried that larvae from local hatcheries were not good enough and might carry diseases, making farmers lose money. Like the meat industry in Vietnam, the government encouraged farmers and consumers to adopt a modern, industrial mode of production and consumption (Porter, 2019). Big foreign shrimp feed companies, like Charoen Pokphand, Uni-President, and Grobest, established their hatcheries in Ninh Thuận because of the better water quality, stable climate, and low-risk environment for shrimp disease. Farmers and business owners, such as Ming-Yi (a Taiwanese capitalist), prefer to purchase SPF larvae from hatcheries owned by foreign shrimp feed companies in Ninh Thuận because of their high quality. However, when farmers buy SPF larvae of whiteleg shrimps from famous shrimp breeding companies, such as Charoen Pokphand (CP) and Uni-President, they also need to buy their shrimp feed as a package. These companies only sell their SPF larvae with shrimp feed as a package since they earn more money from the feed than larvae. Hatcheries of giant freshwater shrimp are run by the governmental aquaculture research institute and provincial agriculture breed centres in the Mekong Delta. They used to produce the postlarvae of black tiger shrimp and crab but transited to the production of giant freshwater shrimp due to the market competition with family hatcheries. Producing the larvae of giant freshwater shrimp is less lucrative than whiteleg shrimp and black tiger shrimp.

4.2.2 Nurturing broodstocks

Nurturing broodstocks includes (1) preparing water, (2) trafficking broodstocks, (3) breeding broodstocks, and (4) creating a mating atmosphere for shrimp reproduction. The following analysis is based on interviews and field trips to five hatcheries: three hatcheries in the Mekong Delta and two hatcheries in Ninh Thuận (Figure 7). In the Mekong Delta, I visited one Vietnamese family hatchery breeding black tiger shrimp and two governmental hatcheries growing giant freshwater shrimp. In Ninh Thuận, I worked with a scientific hatchery (whiteleg shrimp) run by a Vietnamese scientist Dr Anh and a family hatchery (whiteleg shrimp) operated by a Chinese Malaysian, Ching-Shin. These hatcheries reflect different relations of water-shrimp-human-environment in nurturing broodstock and propagating larvae.

First, hatcheries prepare water before breeding broodstocks. In the Mekong Delta and Ninh Thuận, every hatchery extracts seawater, river water, and groundwater for free. The government neither regulates nor charges money for water extraction. The differences between the Mekong Delta and Ninh Thuận are water resources and water quality. In the Mekong Delta, water salinity is around 35‰, but during the rainy season, it drops down to 29‰. If water salinity is not high enough for the broodstock, they make saltwater and add it to the tanks. When water salinity is too high, they might extract groundwater to decrease water salinity. In Ninh Thuận, hatcheries extract free seawater by extending their pipelines into the ocean. They pump seawater during the high tide because it is cleaner. Before using water, every hatchery treats water for two or three days in water treatment ponds. Water treatment ponds are at least twice as large as their water tanks since hatcheries require lots of water to change the water every day. For breeding broodstock and larvae, they need to remove and filter sediments, algae, and other materials from the seawater, disinfect bacteria with chlorine within the saline water and oxygenate the water a day before using it (Figure 9).

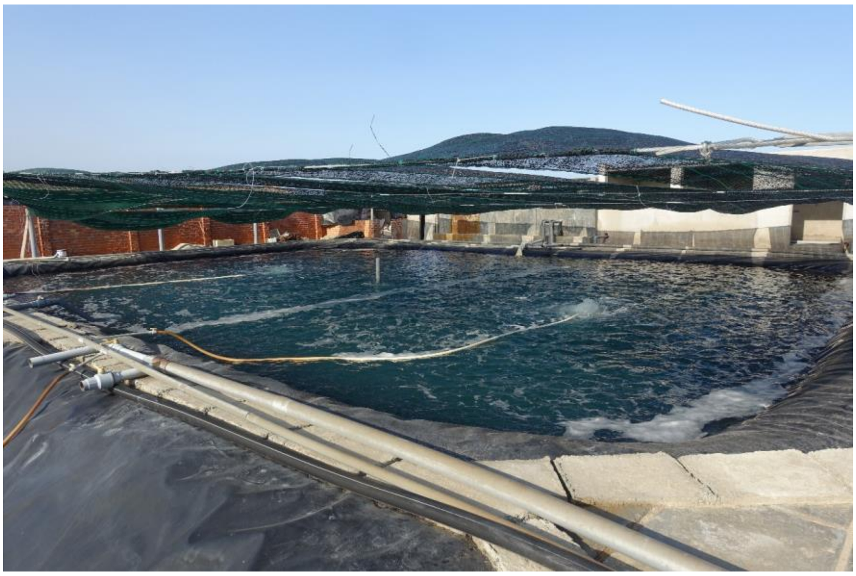


Figure 9 Preparing saline water

Source: Author

Second, broodstocks are bred, harvested, and delivered to hatcheries from different routes. Hatcheries tend to obtain SPF broodstocks to ensure that no pathogen is imported to their breeding tanks. The broodstock of whiteleg shrimp is specific-pathogen-free and well developed by foreign companies, such as the Charoen Pokphand Group, Shrimp Improvement Systems (SIS), and Koran Bay. Ching-Shin bought his broodstocks from SIS, and the broodstocks were delivered from Florida. SIS provided photos of broodstock in Florida and explained that the American staff controlled the salinity and pH value properly (Figure 10). After that, SIS sent the cultured broodstocks to hatcheries in Ninh Thuận. When the broodstocks arrived in Hồ Chí Minh City, the government did diagnostic testing to ensure specific pathogens were not imported. Generally, it took 20 days from delivery to finish the testing.

Figure 10 Packing the broodstocks in Florida
Source: Ching-Shin Chou

Compared to buying broodstocks of whiteleg shrimp from foreign companies, the transaction of black tiger shrimp broodstocks depends on unstable and irregular catches from fishers. Hatchery owners in the Mekong Delta usually call merchant-fishers in Cà Mau to buy the broodstock of black tiger shrimp. Still, wild broodstocks of black tiger shrimp might carry pathogens and infect the hatchery environment or farmers' shrimp ponds. Hatchery owners in the Mekong Delta do not have any scientific equipment to check for viruses and diseases, although some would purchase laboratory testing services. Therefore, it is more challenging to practise biosecurity for black tiger shrimp.

Giant freshwater shrimp do not have SPF broodstocks, but hatcheries only produce male larvae since the size of male shrimp is bigger and more marketable than the female one. Hatcheries control the larva gender by removing the androgenic gland, a tissue controlling gender characteristics, from the female broodstock. With this biotechnology, female broodstocks can only produce male larvae after mating. The broodstock of giant freshwater shrimp is bred on shrimp farms, but their larvae travel to hatcheries in coastal provinces in the Mekong Delta. The broodstock of giant freshwater shrimp lives in lower water salinity around 10-15%, but the larvae require higher water salinity.

Third, broodstocks of whiteleg shrimp and giant freshwater shrimp need to be nurtured before mating and after travelling a long distance to hatcheries. Broodstocks of black tiger shrimp are usually mated in the sea so that they are nurtured for giving birth rather than mating. Technicians and workers nurture broodstocks through diverse practices that include both traditional and scientific methods. Ching-Shin has been in Vietnam for 20 years as a broker and coach for broodstock trading and shrimp reproduction. He started his hatchery in Ninh Thuận ten years ago. He is the pioneer in bringing the broodstock of whiteleg shrimp from the US to Vietnam. While preparing water, Ching-Shin added Chinese herbal medicine into the water to kill the bacteria. In the first ten days having arrived at the hatchery, Ching-Shin fed broodstocks with decent foods, such as bloodworms (Glycera), oysters, and squids (Figure 11). Before feeding broodstocks bloodworms, Ching-Shin fed the bloodworms Chinese medicine. He thought that bloodworms have bad germs within their intestines, and the Chinese herbal medicine could kill bacteria to protect his broodstocks. After that, Ching-Shin cut one of the eyes of broodstock (eyestalk ablation), which can stimulate broodstocks to secrete a kind of hormone. As a result, they produce more eggs in their ovaries. It is also a common method to boost the productivity of broodstocks in family hatcheries in the Mekong Delta (also in Taiwan and Bangladesh, see Hinchliffe et al., 2018: 4). But once an eye is cut, broodstocks get sick easier and require more care.

In contrast, Dr Anh adopted a scientific method to nurture his broodstocks. Dr Anh's employees are scientists with aquaculture degrees, and his hatchery in Ninh Thuận has a laboratory with state-of-the-art equipment. Thus, Dr Anh and his research team do PCR testing every time before feeding broodstocks with bloodworms, oysters, and squids, but not Chinese herbal medicine. They did not cut any eye from broodstocks because they believed that broodstocks propagate better quality larvae without any injury.

Figure 11 Bloodworms in Ching-Shin’s hatchery
Source: Author

They both have a thorough labour division to care for broodstocks and larvae. Capitalist hatchery owners usually hire workers and technicians and ask them to live in the accommodation to take care of broodstocks and larvae for 24 hours, such as feeding broodstocks and larvae every few hours and handling any emergent events. Hatcheries run by foreign companies in Ninh Thuận usually recruit scientists to conduct biosecurity practices, such as PCR testing and laboratory management, to reduce the risk of shrimp disease in their hatcheries. The biosecurity practice is not only about the arrangement of technology and devices but also about labour management. In Dr Anh’s hatchery, there were posters on doors written to workers that do not use any antibiotics. Since some workers were afraid of larvae dying and used antibiotics to prevent death, Dr Anh must do microbiological testing to ensure that his shrimp are antibiotics-free.[7]

[7] Antimicrobial products are also used in Bangladeshi hatcheries for three reasons (Hinchliffe et al., 2018). First, it is used for various purposes, such as treating infected broodstocks, brine shrimp with

Fourth, the hatchery creates an aquatic animal atmosphere to stimulate certain behaviours (Lorimer et al., 2019; Barua, 2021). When broodstocks are ready to mate, workers need to create a mating atmosphere, such as the length of day and night time, tank colour, and water transparency. On the field trip to Dr Anh's hatchery in Ninh Thuận, Huỳnh, a researcher and hatchery manager, guided me to the mating room in a dark warehouse. Huỳnh turned on his flashlight and walked in front of me. He lit up a machine clock on the wall beside the entrance (Figure 12). Before mating, workers needed to open the light and turn off the light for 12 hours to mimic the daytime and nighttime for broodstocks as a natural environment. It was nighttime for broodstocks, and the room was very dark. At the end of the warehouse, one worker was walking in the mating pond and wearing a headlamp to spot pregnant female whiteleg shrimp. Broodstocks swam leisurely within the mating tank. Their size was bigger, and their colour was darker than young whiteleg shrimp on the shrimp farm. Typically, male and female broodstocks are bred separately in different tanks. Only when female broodstocks have eggs on their body will they be moved to the mating tank. The mating tank was painted black, food residues were left in the tank, and the water looked hazy. Unlike other tanks in the hatchery that were kept tidy and hygienic, mating tanks were intentionally kept like this to mimic the wild and natural environment so that broodstocks could mate. Workers were critical caregivers since they were very experienced and knew which broodstock had eggs. As with the case of the Vietnamese chicken hatchery, workers attuned their bodies and senses to the status of broodstocks in the darkroom (cf. Porter, 2019: 58-60). A worker caught a fertilised broodstock and showed me her eggs around her legs (Figure 13). The eggs were already fertilised, and these female broodstocks were brought into the spawning tank for 2 hours and moved

Vibrio infection, or slow growing larvae. Second, technicians use antimicrobial products as treatment on trials. Third, technicians found some products ineffective and utilised more antimicrobial products.

back to their original tank (Figure 14).

Figure 12 Timers for switching daytime and nighttime

Source: Author

Figure 13 A pregnant broodstock and her eggs

Source: Author

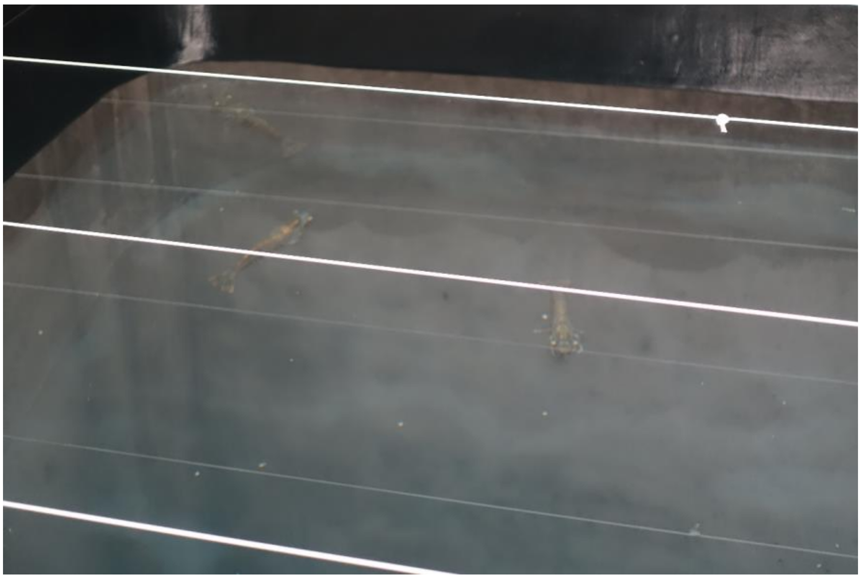


Figure 14 Pregnant shrimps in the spawning tank
Source: Author

Due to governmental regulation on the quality control of broodstock and larvae, the life length of broodstock is only four months: one month for testing and preparation and three months for breeding. After four months, public servants would visit the hatchery, ask owners to destroy all broodstocks, and take photos as evidence. Ageing broodstocks cannot breed good quality larvae and might affect the Vietnamese shrimp industry. Thus, hatcheries in both Ninh Thuận and the Mekong Delta usually import broodstocks of whiteleg shrimp three to five times per year. The broodstocks of black tiger shrimp are usually caught by fishers, and the female broodstocks are already fertilised in the sea. Sperm from male broodstocks are stored in the receptacle of female broodstocks. Hatcheries in the Mekong Delta only nurture and breed the broodstocks and do not do any mating work. They usually keep the broodstocks of black tiger shrimps for 75 days and release them to the ocean.

4.2.3 Propagating larvae

Larvae are bred with intensive care and biosecurity concerns. In shrimp aquaculture, hatcheries produce shrimp from fertilised eggs, nauplii, zoeae, mysis to the postlarvae (Figure 15). It takes one month to grow up to postlarvae (8-12 days) as a commodity to sell to farmers. Fertilised eggs are tiny and mixed with oxygen bubbles in a water tank. It was difficult for me to see these eggs in the water, but experienced workers spotted fertilised eggs and moved them into a small tank. Once eggs are hatched out as nauplius in Dr Anh's hatchery in Ninh Thuận, they are placed in a double washing system. Nauplii were within the inner water bucket with nets to allow water to flow to the outer bucket, and the water was overflowing to the floor (Figure 16). This washing system cleaned up dirt on the body of nauplii. After several days, workers moved the nauplius into other water tanks in other warehouses (Figure 17). There were around 18 water tanks in a warehouse. The water was filtered by cotton bags in the holes of pipelines and changed every five days. Each tank was covered by plastic mats to protect water quality and maintain the temperature. Larvae should be kept with water temperature not lower than 27°C so that warehouses were intentionally kept very warm. During the dry season, larvae grow faster under the higher water temperature; and during the rainy season, they grow slower with the lower water temperature. Huỳnh picked up a glass from a brown water bucket, which was disinfected, and scooped up a cup of zoeae from the water tank. It was hard to see these tiny zoeae from the glass.

Figure 15 The postlarvae of black tiger shrimp on the 20th day
Source: Author

Figure 16 Double washing system to wash away the eggshell and other toxic materials on the body of nauplius

Source: Author

Figure 17 Water tanks for larvae in Dr Anh's hatchery

Source: Author

There are two ways to identify the life stage of shrimp. One method is that workers observe the swimming direction of larvae. Zoeae and mysis swim backwards, but postlarvae swim forward. The other one is that workers write down the day of breeding on a whiteboard on the wall. It is important to know the life stage of larvae so that workers can provide suitable feed.

Zoeae and mysis only eat algae from the laboratory, while postlarvae eat both algae and brine shrimp. Hatcheries buy the dormant cysts of brine shrimp and incubate them by themselves. In Dr Anh's hatchery, all the brine shrimps must be tested as pathogen-free before being used. In governmental hatcheries in Bạc Liêu and Cà Mau, a manager fed the postlarvae with Taiwanese nutrient products to improve good germs in shrimp intestines and restrain bad germs in the water.

For selling postlarvae, hatcheries adjust water salinity to the local condition in shrimp ponds. Since water salinity in hatcheries is around 30‰, but water salinity in shrimp ponds is from 5‰ to 7‰, hatcheries in Ninh Thuận and the Mekong Delta need to decrease water salinity before delivering postlarvae. Hatcheries of giant freshwater shrimp need to reduce water salinity from 10-15‰ to 2-3‰. There are two ways to determine water salinity. One way is that farmers measure the salinity of their ponds with a simple salinity indicator and inform the hatchery. The other way is that farmers bring a bag of water from their shrimp ponds to the local family hatchery in the Mekong Delta. The family hatchery decides which postlarvae suit the water quality of shrimp ponds. Some farmers in the Mekong Delta believe that postlarvae from local hatcheries are already acclimatised to the local environment, which is better than the SPF postlarvae from Ninh Thuận. Some farmers in Bangladesh have a similar belief that wild-caught postlarvae are acclimatised to shrimp ponds (Hinchliffe et al., 2020: 3). After determining water salinity, hatcheries add freshwater into the tanks to decrease the salinity by 2-3‰ every three hours and complete it within 1-2 days. If the postlarvae are healthy enough, they can finish it quicker. There is plenty of free saline water but not enough freshwater in Ninh Thuận. Thus, hatcheries in Ninh Thuận buy freshwater from other provinces. After treating purchased freshwater, they add it into water tanks to decrease water salinity.

After water salinity decreases and postlarvae are ready to deliver, hatcheries create a mobile capsule to deliver these lively commodities. Hatcheries pack postlarvae of whiteleg shrimp and black tiger shrimp from the 8th-12th day and the postlarvae of giant freshwater shrimp from the 34th-37th day in transparent plastic bags with enough water, oxygen, and brine shrimp. Postlarvae are tested as specific-pathogen-free by PCR testing before selling to farmers. In Dr Anh's hatchery, they pack 800-900 big postlarvae into a bag and 1,200-1,300 small postlarvae into a bag by using a sieve to filter the water and count the number of postlarvae. In the governmental hatchery of giant freshwater shrimp, 200-270 postlarvae of giant freshwater shrimp are packed into a bag since they are grown longer. Postlarvae must be delivered by refrigerator vans to farmers within 24 hours. Otherwise, postlarvae would have nothing to eat and start to eat other larvae.

This section has unpacked the industrialisation of shrimp reproduction in hatcheries from hatchery geographies, nurturing broodstocks, and propagating larvae. First, the operation of shrimp hatcheries is affected by shrimp species and broader environments. Whitleg shrimp and black tiger shrimp require higher water salinity; while giant freshwater shrimp live in lower water salinity. Thus, different types of shrimp hatchery are located either in the riverine Mekong Delta or in Ninh Thuận with the arid climate because of water quality, water temperature and the availability of broodstocks. Furthermore, the nature of shrimp hatcheries influences the forms of social organisation, like family, shrimp feed companies or governmental business. Second, nurturing broodstocks in the hatchery requires mimicking the living environment of broodstocks, capturing or importing broodstocks from various routes, managing their health status, and creating the animal atmosphere to stimulate mating behaviours. These three types of broodstocks assemble different water-shrimp-human-environment relations to reproduce larvae. Third, hatcheries reproduce larvae with intensive care, such as managing water quality and food. Before animal trafficking, water-shrimp-human-environment relations are reconfigured in order to fit conditions of shrimp farms in the Mekong Delta.

4.3 The supporting industries for shrimp farming

Breeding shrimp not only cares for the water and shrimp itself but also needs to produce the proper food in each life stage. From nauplius to mysis stage, larvae in hatcheries eat algae and brine shrimp; shrimp in ponds eat artificial feeds or are fed by natural food in the Mekong Delta. Therefore, scientists, farmers, and companies also domesticate algae and brine shrimp to maintain the life of larvae. They then industrially produce algae and brine shrimp to fulfil the industrial needs of the shrimp industry. Hence, lab-like hatcheries produce pathogen-free algae and farmers in the Mekong Delta breed brine shrimp. The domestication and production of algae and brine shrimp are a form of real subsumption of nature that supports hatchery operation. When the food that cannot be cultivated becomes a natural obstacle, companies develop artificial shrimp feed to meet the enormous demand of shrimp appetite. Thai and Taiwanese shrimp feed companies buy Chilean fish powder and process their products near Hồ Chí Minh City. Artificial shrimp feed pellets are a kind of appropriation, as companies manufacture fish powder into an industrial product and sell it to farmers as a commodity input (Boyd et al., 2001).

In the next section, I focus on the operation of support industries (or upstream sectors) for shrimp farming via three examples: (1) the hydro-social life of algae in Dr Anh’s hatchery, (2) brine shrimp farming in the Mekong Delta, and (3) the production and business of shrimp feed in a Taiwanese factory and in the Mekong Delta.

4.3.1 Cultivating algae in a lab-like hatchery

Feeding is a form of species encountering. Algae are the first food that larvae eat in their life. Dr Anh only produces certain kinds of algae, such as *Thalassiosira pseudonana*, *Tetraselmis tetrathele*, *Chlorella vugris* as a group, and *Chaetoceros gracilis*, *Chaetoceros calcitrans* as another group in bottles. The selection and combination of algae are based on algae's size, digestibility, nutrient, and economic effectiveness. Only algae of the proper size and easy to digest for larvae have economic effectiveness to propagate in hatcheries. The combination of different algae provides various nutrients for larvae, which is better than a single kind of algae. The encounter of algae and larvae in hatcheries is framed with the biological evaluation and economic calculation.

Due to biosecurity concerns, algae for hatcheries are cultivated in a lab-like environment since wild algae might carry pathogens. On the field trip to Dr Anh's hatchery, Huỳnh brought me into the room for producing algae. We took off our shoes and sanitised our hands before entering the room. The interior design of the room is like an office, with air conditioners to maintain the room temperature low. A female worker was sitting in the room and looking at every bottle. They used plastic bottles to cultivate a huge amount of algae in the limited space, provided oxygen with pipelines, and utilised fluorescent lamps to accelerate algae production. They put the UV light within the biggest grey plastic pipeline on the wall to kill the bacteria within the air before pumping oxygen into the bottles. All these settings were to eradicate any risks for biosecurity in the hatchery. They wrote the start date of production on the bottles, and it takes three days to produce algae. The water colour showed algae development: darker colour means more algae in the water (Figure 18). Dr Anh produced algae for his hatchery and sold it to other hatcheries that did not cultivate algae, such as Ching-Shin. This hydro-social life involves biosecurity and is embedded in a well-controlled environment.

Figure 18 Cultivating algae in an air-conditioned lab
Source: Author

4.3.2 Breeding brine shrimp in the Mekong Delta

Brine shrimp are another species that must be drawn into the larviculture industry. Brine shrimp nauplii is a high nutrient food for the larvae of shrimp and fish. It is widely used in larviculture and the aquarium industry. Although hatcheries in Vietnam mainly import high-quality brine shrimp cysts from other countries, brine shrimp farming in the Mekong Delta provides a new aspect of hydro-social life. It illustrates the ecological condition of brine shrimp production and illuminates the private company and governmental cooperatives for raising brine shrimp.

Brine shrimp farming is deemed as a poverty alleviation industry by the Bạc Liêu government. Brine shrimp are more lucrative than whiteleg shrimp or black tiger shrimp because they do not have any risk of shrimp disease. For instance, in 2019, the Global Environment Facility (GEP) small grants programme launched an experimental project on brine shrimp farming in the village to cope with poverty and climate change (Đoàn Thanh niên Cộng sản Hồ Chí Minh tỉnh Bạc Liêu, 2019). As a result, some farmers in the Mekong Delta were able to shift from salt farming, black tiger shrimp, or whiteleg shrimp farming to brine shrimp farming to cope with salinisation.[8] However, due to land-use regulations and economies of scale, not all farmers can transition into brine shrimp farming. In my fieldsite in Bạc Liêu and Sóc Trăng, there were two kinds of social organisation in the brine shrimp industry: private enterprise and governmental cooperative. With the introduction of my informant, I met Long, a peasant enterpriser, on his brine shrimp farm. Long bought lots of land in the village, owned around 70 shrimp ponds, hired three villagers as workers, and had a huge truck to deliver his products. With these economies of scale, he had his brand sell the eggs within the Vietnamese domestic market. However, due to the limit of market access, Long was not able to sell to overseas markets. In a nearby village, most brine shrimp farmers attended a famous state-owned cooperative. The cooperative bought dormant cysts from farmers and sold them to foreign countries since farmers cannot process and sell their products to markets alone. Thus, brine shrimp farming as poverty alleviation is related to social organisations in the village.

In brine shrimp farming, hydro-social life has distinctive interconnections between the flexibilities of brine shrimp and the ecological condition of brine shrimp production (cf. Bustos-Gallardo et al., 2021). Brine shrimp can reproduce active young larvae and dormant cysts under different water salinity and oxygen levels. Under high water salinity or low oxygen, female brine shrimp would produce dormant cysts (Figure 19). For farmers, dormant cysts are preferable to active embryos for markets because they

[8] Bến Tre is another province in the Mekong Delta planning to develop the brine shrimp industry.

are less fragile and can be preserved for one to two years. Compared to whiteleg shrimp

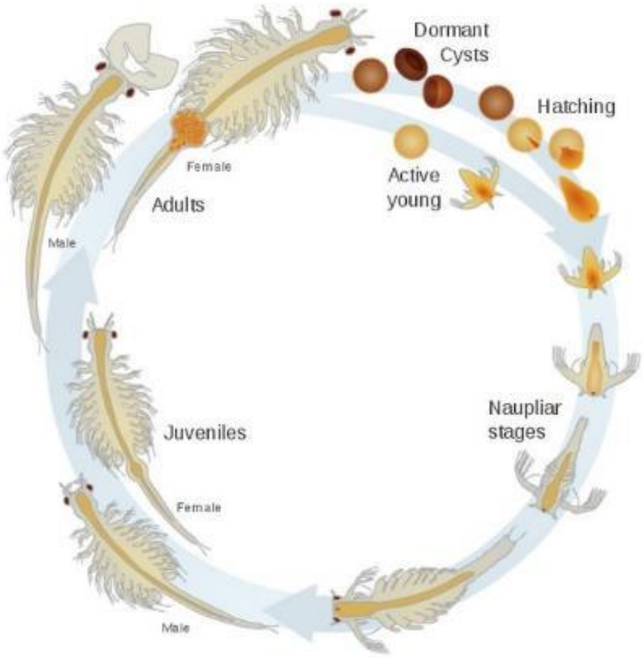


Figure 19 The life cycle of brine shrimp
Source: (Learn.Genetics, unknown year)

and black tiger shrimp, brine shrimp require higher water salinity (45‰ - 300‰). The salinity of the river in Bạc Liêu is around 20‰ to 30‰. Therefore, during the dry season (from December to July), Long imported plenty of saline river water several times and made saline water (làm nước mặn) up to 50‰ or even 80‰-120‰ (Figure 20). Once the water was sufficiently salty, he stopped importing water since the river water alone was not salty enough. Brine shrimp do not have severe diseases like whiteleg shrimp and black tiger shrimp so that he did not worry about water quality. He fed brine shrimp chicken manure rather than commercial shrimp feed. During the rainy season, afternoon thunderstorms lower water salinity, so in the rainy season Long usually stops breeding brine shrimp and, instead, breeds either whiteleg shrimp or black tiger shrimp.

Figure 20 Long's brine shrimp ponds
Source: Author

Due to physiology and the life cycle of brine shrimp, the spatiality and temporality of brine shrimp farming are more concentrated and shortened. Brine shrimp can be reproduced in a single site rather than in different sites, like giant freshwater shrimp, whiteleg shrimp, and black tiger shrimp. One afternoon, I visited Long's brine shrimp hatchery in the middle of the shrimp farm, where Long and his workers used an air pump to incubate brine shrimp larvae (Figure 21). Unlike breeding whiteleg shrimps and black tiger shrimp, Long did not buy postlarvae from a hatchery but reproduced the nauplii from his product dormant cysts. It was straightforward to incubate the brine shrimp by washing dormant cysts, adding saline water (around 15‰) into plastic blankets, providing enough oxygen, and waiting 24 hours. Whiteleg shrimp and black tiger shrimp hatcheries and individual pet fish owners also adopt the same method to incubate nauplii to feed larvae and pet fishes. After being incubated, the nauplii of brine shrimp were released into shrimp ponds. Long can start to harvest the eggs almost every day after seven days. Female brine shrimp can produce up to 300 offspring every four days, and productivity reaches its peak from the 30th-40th day. The rhythm of harvesting dormant cysts also depends on the timing of wind flow. During the interview, Long told me that we needed to wait for the “wind” for harvesting. While we felt the wind blowing on us, we walked to the shrimp ponds. Long led me to the corner of the shrimp ponds. The wind agitated the water. Tiny eggs and dead bodies were pushed to the corner of the shrimp pond and floated on the water surface (Figure 22). If there was no wind the whole day, they would not harvest any eggs. In the hydro-social life of brine shrimp, farmers utilise the flexibilities of brine shrimp to create a high saline water condition and meet market preferences. The ecological production of brine shrimp is still shaped by natural processes in the delta, such as the dry season for making higher water salinity and wind concentrating brine shrimp eggs in one area of shrimp ponds.

Figure 21 Using an air pump to incubate brine shrimp larvae

Source: Author

Figure 22 Brine shrimp eggs are blown to the corner of the shrimp pond by wind
Source: Author

4.3.3 The production and business of shrimp feed in a Taiwanese company and the Mekong Delta

Shrimp feed is an artificial food that substitutes natural foods to boost the development of the shrimp industry. Hau-Ting, the general manager of a Taiwanese shrimp feed company, argued that his customers are both farmers and unspeaking shrimp because it is shrimp that ultimately eat his products. Making good shrimp feed is crucial for shrimp and this industry. Good shrimp feed should meet three criteria: good stability, a high feed conversion ratio, and the enhancement of shrimp health. First, it is important to make a stable shrimp feed that would not dissolve before shrimp eat it. Ideally, shrimp should finish a certain amount of feed within 1.5-2 hours. If shrimp do not finish pellets, they dissolve into the water and deteriorate water quality, which might cause shrimp disease. Second, the feed conversion ratio influences the farmer's investment. A higher feed conversion ratio could save lots of money for farmers. Interestingly, Hau-Ting developed a series of booster feeds to accelerate the growth rate of shrimp and shorten the production time after the 50th day. These booster feeds were only sold in Vietnam. Hau-Ting's shrimp feed is sold to Taiwan and other southeast Asian countries, but only

Vietnamese farmers are willing to buy booster feeds; even he cannot explain this distinctive market niche. Third, the nutrition of shrimp feed should be easily digested and absorbed by shrimp to become healthier. Farmers can evaluate the quality of feed from the growth rate of shrimp, the hardness of shrimp shells, and the gill and intestine of shrimp. When shrimp are full and digest well, they would have a black line of excrement in their intestine and to their bottom.

Shrimp feed accelerates the production time of shrimp. According to the stage and weight of shrimp, shrimp are provided with certain amounts of feed around 2-5 times per day. For example, as postlarvae (the 10th-15th day), shrimp are fed with the amount of shrimp feed around 25%-30% of shrimp weight two times per day (50% at 6 am and 50% at 5 pm); when shrimp are over 15g (or 76 days), farmers need to feed the amount of shrimp feed no more than 3% of shrimp weight 4-5 times per day (30% at 6 am, 20% at 11 am, 30% at 5 pm and 20% at 10 pm). The actual feeding schedule is adjusted according to weather and water temperature. When water temperature is above 25 ℃, shrimp eat more and grow faster; while water temperature is above 25 ℃, shrimp eat less and grow slower. It is crucial for farmers to weather and water temperature so that they can decide to provide how much shrimp feed and maintain water quality. Furthermore, shrimp feed can help farmers fulfil the hunger of shrimp and align the growth rate of shrimp to avoid cannibalism. Shrimps are cannibalistic, have territorial behaviour, and moult their shell from 3 days to 15 days, depending on their life stage. When shrimp density in ponds is high and their timing of moulting is not aligned, some shrimp will eat other soft and moulted shrimp. Thus, keeping the maximum population of shrimp in ponds does not lead to the optimum income, but shrimp feed can mitigate the discrepancy of moulting timing.

Shrimp feed has to fit with the aquatic environment and biosecurity requirements.

Before packing shrimp feed, shrimp feed companies have three quality control stations. In the first quality control station, workers check the size of feed and feed density. Workers used rulers to measure the size of feed and put it into cups of water with salinity at 10ppm (Figure 23). Shrimp feed is supposed to sink since shrimp are benthic animals and only eat sinking pellets.[9] To conduct this check, the factory — which is in an industrial park far from the sea — needed to prepare saline water and mix it with freshwater to have water salinity at 10ppm. In the second quality checkpoint, shrimp feed is brought to two labs to check physical and chemical components, such as the proportion of protein and water. Third, shrimp feed is tested by PCR testing for the biosecurity concern about African swine fever and Halal requirements. Shrimp feed is mainly made of fish powder from Chile and was dried and processed with high pressure and temperature before delivering to Vietnam. Water is extracted from fish substances to suspend the bacterial process of decay and exclude any disease vector for shrimp (Lien, 2015: 120). Yet, shrimp feed should not contain any pork or beef ingredients since these products are sold to Taiwan, where the government has a biosecurity policy on African swine fever. Shrimp feed is also sold to other Muslim countries, such as Malaysia and Bangladesh, so it must meet Halal requirements. This case showed that the inclusion and exclusion of certain species into the feed is related to biosecurity and social practices across borders. After being checked, the feed was stored in bottles in a storage room in case the shrimp feed company receives any complaints about their products and needs to conduct follow up checks. Shrimp feed is not merely an independent product but a crucial part of the food network.

[9] The factory also produces fish feed but with more complicated design. There are two kinds of pellets for fish: sinking pellets and floating pellets for freshwater fish and marine fish.


Figure 23 A checking station in the shrimp feed factory with freshwater and saline water
Source: Author

Even having decent shrimp feed products, Hau-Ting, as a Taiwanese company, still relied on Vietnamese managers to enter the Vietnamese market in the countryside. Most shrimp feed companies are foreign companies, and they have to build up social ties with local societies. As a new company in the Vietnamese shrimp feed market, Hau-Ting believed that they should utilise scientific knowledge and professional services to expand their market rather than drinking alcohol and building camaraderie with Vietnamese, like other foreign shrimp feed companies. With Hau-Ting's introduction, I had a chance to visit Hùng, a senior provincial manager of the Taiwanese shrimp feed company in Bạc Liêu. In his team, ten junior technicians were trained in aquaculture. All the technicians and Hùng either own private shrimp ponds or have shrimp farming experience. Hùng told me that if technicians want to sell shrimp feed to others, they need to know how to breed shrimp. Otherwise, it was not persuasive that they could help farmers to solve their problems. They are not just selling products but also providing after-sales services since shrimp feed is a continuous operation cost for farmers in intensive and super-intensive shrimp farming. Nevertheless, all the shrimp companies in Vietnam develop sales agent models to prompt their products. In this business model, regional managers cooperate with local retail shops, which are also called as sales agents (đại lý) (Figure 24). Local retail shops sell shrimp feed, probiotics, minerals, and nutrient products, becoming a vital social space for farmers and sales agents to meet. Most of the sales agents are residents and themselves breeding shrimp to know how to use their products and explain them to their customers. Shrimp feed is sold to villagers through the network of regional managers and local sales agents.

Figure 24 A billboard of a sales agent in the village
(It is written: *The sales agent of the Taiwanese shrimp feed. Providing feed for black tiger shrimp, Scambi-Super Grown whiteleg shrimp, aquatic animals medicine, and high-quality specific pathogen-free larvae*.)
Source: Author

Farmers usually get shrimp feed first and pay the fee later. But if the outbreak of disease causes bankruptcy, they then need to sell their lands and shrimp in the ponds to shrimp feed companies. In an interview with a previous Taiwanese feed company in Vietnam, a businessman told me they stopped running the shrimp feed business. When shrimp disease outbreaks on the farm, shrimp feed companies could not get the money back and receive many lands and red books (the Vietnamese land ownership certificate is in a red book) from farmers. However, according to Vietnamese law, foreigners are not allowed to have land ownership. For example, a Taiwanese shrimp feed company let its Vietnamese workers own those lands by signing the acknowledgement of debt to protect the company's land property.[10] Bankrupted farmers became tenants of the shrimp feed companies who now own the land. Farmers do shrimp farming for shrimp feed companies. Due to the high risk in the shrimp feed market, the Taiwanese company closed down their shrimp feed production in Vietnam.

Hau-Ting's company adopted a new business model in the Mekong Delta. They sold shrimp feed to local sales agents in the village. Sales agents sold shrimp feed to Vietnamese farmers. In this business model, sales agents paid all the fees to the Taiwanese company when they obtained the feed. They absorbed the risk of non-payment from farmers. Sales agents earned money when the farmers harvested and sold their shrimp. Before cooperating with the Taiwanese shrimp feed company, sales agents needed to provide a financial statement and could not sell other brands of shrimp feed. Tuấn, a Vietnamese sales agent of Hau-Ting's brand, mortgaged his house to a bank as his financial statement. Therefore, Vietnamese sales agents take the risk of unpaid bills from farmers rather than the Taiwanese company. Hùng told me that their company and sales agents nowadays preferred to sell shrimp feed to farmers doing super-intensive shrimp farming in plastic ponds with better biosecurity practices. They did not like to sell their products to farmers doing intensive shrimp farming in soil ponds with higher risks of shrimp disease. In other words, sales agents become investors in more biosecure farming as a way to decrease the risk of non-payment. In the worst case, Tuấn said that some of his clients owed him money. He came up with a solution that he invested in

[10] Wang (2019) has pointed out, in Vietnam, it is common for Taiwanese businessmen having Vietnamese wives or partners and letting them own some land properties, but also ask them to sign the acknowledgment of debt to avoid being cheated.

and upgraded shrimp ponds of his clients into super-intensive shrimp farming to help them reduce the risk of shrimp disease. Tuấn did not charge any interest in this investment. Farmers only paid Tuấn the debt and the investment fee back when they could earn money. After that, farmers can own all the equipment. Selling shrimp feed is in this way entangled with economic transactions, social relations, and biosecurity (human-animal relations) in shrimp ponds (cf. Henderson, 1999). In short, the shrimp feed business plays a significant role in shaping hydro-social life on the shrimp farm.

4.4 Conclusion

This chapter analysed how the hatchery contributes to the formation of shrimp economies by shrimp domestication, the industrialisation of shrimp reproduction, and the development of supporting industries. It explored the birth of shrimp hatcheries by reviewing the histories of shrimp domestication in Japan, Taiwan, and America. I have shown in this chapter how three kinds of shrimp (whiteleg shrimp, black tiger shrimp, and giant freshwater shrimp) are industrially reproduced, drawing on my visit to shrimp hatcheries and interviewing business owners, technicians, and workers in the Mekong Delta and Ninh Thuận. The chapter also investigated the development of supporting industries, drawing on research into algae production in a lab-like hatchery, a brine shrimp farm, a shrimp feed company, and sales agents of the shrimp feed company in the Mekong Delta. Shrimp domestication constructs water-shrimp-human-environment relations by developing a set of techno-scientific practices and multi-species relations in the hatchery on a commercial scale.

First, the birth of shrimp aquaculture and the hatchery arose from innovation by Japanese, Taiwanese, and American scientists in the context of science modernisation, Malthusian concerns over food supply and population, and marine and coastal resource management. The life cycle of shrimp was first unpacked by Dr Motosaku Fujinaga, the father of shrimp farming, in the lab-like hatchery. In the 1930s-1960s, Kuruma shrimp, black tiger shrimp, giant freshwater shrimp, and whiteleg shrimp were artificially propagated in Japan, Taiwan, and America. In the 1960s-1970s, scientists industrialised and commercialised shrimp reproduction by algae and brine shrimp cultivation and shrimp pond innovation. These technologies flourished in Japan and America, and facilitated the modern shrimp farming method worldwide. From the 1990s, scientists developed the SPF shrimp for various species to tackle the risk of shrimp disease. The history of shrimp domestication showed the knowledge and technology network across countries, which shaped water-shrimp-human-environment relations in the hatchery.

Second, the hatchery industrially reproduced shrimp by managing hydro-social life in hatcheries. Hatcheries reproducing whiteleg shrimp, black tiger shrimp, and giant freshwater shrimp are in the Mekong Delta or Ninh Thuận because of the living conditions for shrimp, the source of broodstock, and the nature of social organisations. Hatcheries nurture broodstocks by mimicking their living conditions, capturing or importing broodstocks from the sea or foreign hatcheries, managing their health status, and creating a mating atmosphere for reproducing larvae. Hatcheries cared for shrimp larvae by managing water quality and providing food. When shrimp became a commodity, hatcheries put larvae in a plastic bag of water with lower water salinity, enough oxygen, and food as a mobile capsule for delivering them to the Mekong Delta. Shrimp then move to the growing phase of shrimp economies.

Third, the industrialisation of shrimp farming has facilitated the development of supporting industries, such as algae production in the lab-like hatchery, brine shrimp farming in the Mekong Delta, and shrimp feed companies in Hồ Chí Minh City. Shrimp domestication brought algae production and brine shrimp production into the industry.

They have distinctive hydro-social lives and are industrially produced and reproduced in the lab-like hatchery and on the shrimp farm. The physiology and life cycle of brine shrimp are different from other types of shrimp, and so they are bred in higher salinity conditions and adopt a different commodity form. The production of algae, brine shrimp, and shrimp feed needs to meet the biosecurity requirements of shrimp hatcheries, such as producing in a well-controlled environment and washing before feeding larvae. It has also profoundly caused agrarian and environmental changes within and beyond the Mekong Delta. Brine shrimp farming has been promoted by the Bạc Liêu government and the Global Environment Facility as a poverty alleviation industry for farmers in the Mekong Delta, but only a few farmers can shift to brine shrimp farming because of land-use regulation and the requirement of economies of scale. Foreign shrimp feed companies cooperate with Vietnamese sales agents to sell their products to farmers. The buyer-seller relationship between sales agents and farmers often presents as a debtor-creditor relationship structured by the risk of shrimp disease, which is part of shrimp's hydro-social lives in the growing phase.

Chapter 5. Commercial Shrimp Farming in the Mekong Delta: Commodity Frontier and Hydro-Social Lives

This chapter analyses the growing phase of shrimp economies by contextualising shrimp farming in the Mekong Delta, examining hydro-social lives in four kinds of shrimp farming, and observing the process of shrimp commodification. These four kinds of shrimp farming reassemble water-shrimp-humans-delta relations to grow shrimp into marketable sizes in the Mekong Delta. The capricious deltaic environment can confine shrimp farming but is also utilised and revised by farmers and investors with devices and infrastructure. Respective hydro-social lives in each type of farming are shaped by multiple capitalist and more-than-capitalist relations but cause uneven agrarian, environmental, and technical changes to farmers and investors.

Section 5.1 contextualises shrimp farming in the Mekong Delta as a commodity frontier with multiple spatialities and temporalities, including national afforestation policy, actions to adapt to climate change, the role of the Kinh and Khmer communities in Vietnam, and foreign capital investment. The multiple spatialities and temporalities of the delta form the context for four kinds of shrimp farming: integrated mangrove-shrimp farming, improved extensive shrimp farming, intensive shrimp farming, and super-intensive shrimp farming.

In Section 5.2, I unpack hydro-social lives in the four kinds of shrimp farming from three aspects: (1) ecological productions of shrimp farming, (2) the alignment between the life of shrimp and the everyday life of farmers, workers and investors, and (3) shrimp disease management. Integrated mangrove-shrimp farming is an alternative model to breed organic shrimp and preserve mangrove forests. Improved extensive shrimp farming is widely adopted by farmers at the interface of freshwater and saline water to tackle climate change. Intensive shrimp farming has a higher risk of shrimp disease and affects the livelihood of the Khmer minority. Super-intensive shrimp farming is practised by some farmers, urban elites, and foreign capitalists as a novel model to enhance productivity and reduce the risk of shrimp disease.

Section 5.3 analyses how shrimp are harvested from the Mekong Delta and commodified by different social organisations. Hydro-social lives in shrimp farming finish when shrimp are harvested and unentangled from water-shrimp-human-environment relations. Shrimp then become a commodity in the global market by attaching to market prices and are sold to middle buyers in villages. Further, shrimp transactions are mediated through capitalist and more-than-capitalist relations, such as community ties and governmental cooperatives.

5.1 Contextualising shrimp farming on the commodity frontier

Contextualising shrimp farming in the Mekong Delta shows the heterogeneous composition and multidirectional development of shrimp economies. Even though most farmers and companies produce similar products, whiteleg shrimp, black tiger shrimp or giant freshwater shrimp, they practise different kinds of shrimp farming due to both physical location and social relations. Adopting monoculture or polyculture shrimp farming is influenced by the changing hydrological and ecological conditions in different parts of the Mekong Delta. As for social relations, farmers and companies conduct four kinds of shrimp farming with uneven investment capacities and under different local policies. To illustrate this diversity of physical location and social relations, I highlight four kinds of shrimp farming to illustrate that the Mekong Delta is a commodity frontier with the diversity of physical environments and social relations.

The distribution of these four kinds of shrimp farming is shaped by land-use planning and freshwater and saline water boundary. Farmers actively changed their farmland into shrimp ponds to cope with climate change. The Vietnamese government announced land-use zoning policies and master plans to regulate the distribution of rice and shrimp farming along the boundary of fresh and saline water (also see Marks, 2010: 156; Belton et al., 2011). The boundary of fresh and saline water is along the Highway 1A (Quốc lộ 1A) in Cà Mau, Bạc Liêu and Sóc Trăng (Figure 25). The northern area of Highway 1A is mostly improved extensive shrimp farming (rice shrimp farming); the southern area of that is intensive shrimp farming and super-intensive shrimp farming. Because of salinity intrusion, the northern area shifted from a rice production zone to a rice-shrimp production zone. Farmers there were allowed to do rice farming or rice-shrimp farming in different seasons at the intersection of freshwater and saline water. In the southern area, farmers with more capital are able to upgrade their land from intensive to super-intensive shrimp farming. Integrated mangrove-shrimp farming is in Cà Mau, the southernmost province in and a peninsula of the Mekong Delta. It has the largest area of mangroves (69,000 hectares) in the Mekong Delta (iPEC, 2019). Cà Mau peninsula is a saline water area and is regulated by the Cà Mau government as mangrove forest conservation zone. Shrimp farmers in this area have to plant mangroves while breeding shrimps.

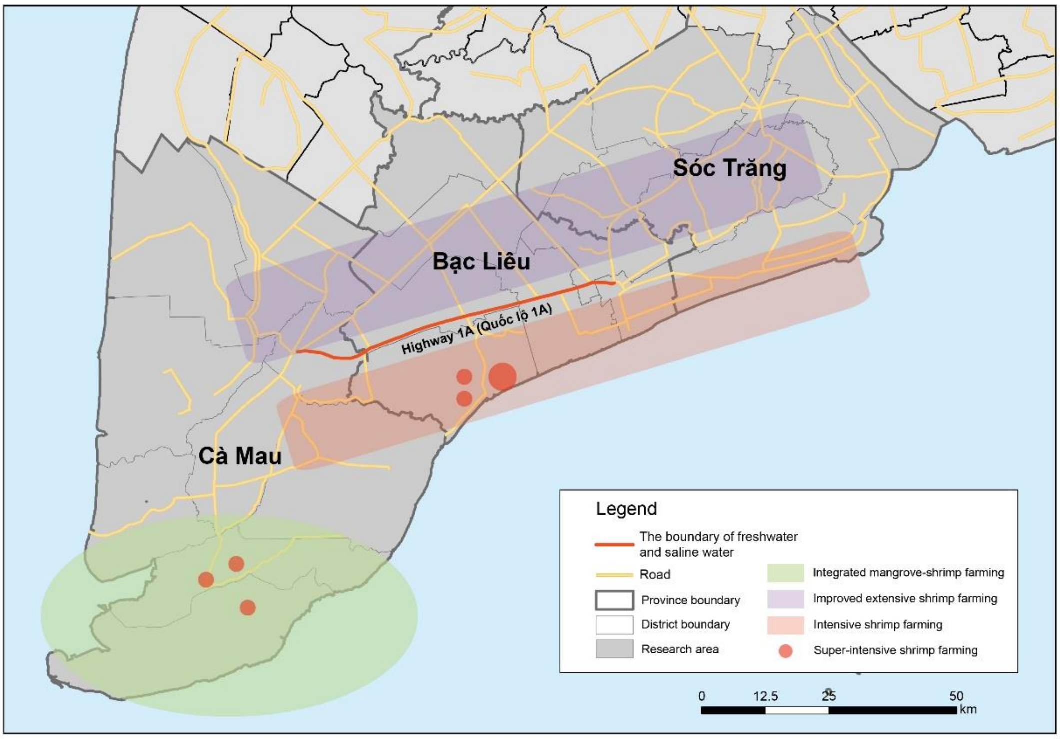


Figure 25 The general distribution of shrimp farming and the boundary of freshwater and saline water.
Source: Author

5.1.1 Integrated mangrove-shrimp farming with Forest Management Boards and an international NGO

Mangrove-shrimp farming was coproduced by farmers, state, and an international NGO under the afforestation and ecosystem service policy. From 1989 to 1995, the mangrove forest in Cà Mau was managed, logged, and sold by Forest Management Boards (FMB), which were state forest enterprises (Lâm trường quốc doanh). At the same time, many Vietnamese, mainly Kinh people (the Vietnamese major ethnic group), moved into this area and illegally occupied the mangrove forest from the state perspective to breed shrimps. In 2003, the mangrove forest in Cà Mau peninsula was mostly replaced by shrimp aquaculture (Binh et al., 2005). In the late 1990s, the Vietnamese government launched a national afforestation policy for recovering bare land and hills (Hai et al., 2020).[11] FMBs shifted their mission from lumbering to mangrove conservation and restoration to prevent coastal erosion. From the 2010s, mangrove reforestation also became an action plan for climate change adaptation and ecosystem service.

According to policy135/2005/NĐ-CP, FMBs could allocate national forest lands to residents to plant trees and conduct aquaculture through a contract of leased forest and land for forest production (giao nhận khoán rừng và đất rừng sản xuất). Except for the flood-prone areas in the coastal region, the local government allocated lands to farmers and readjusted land ownership. Thus, farmers practised mangrove-shrimp farming on national forest lands, which were regulated by FMB. The zoning policy constrained the land use and the distribution of shrimp farming (Vandergeest et al., 1999). The reforestation policy shaped the spatial configuration of mangrove-shrimp farming into longer striped shapes via land ownership redistribution (Figure 26). The Vietnamese government used the afforestation policy as a means of obtaining control over land and people and developing mangrove-shrimp farming (McElwee, 2016: 169). The contracting of forests to individual peasant households is a tool to impose national regulation. The government offered incentives to farmers for managing their forests wisely (cf. Tsing, 2015: 268).

In Nhưng Miên, Care for Mangrove (CfM, pseudonym), an international NGO, brought stakeholders, such as farmers, the governmental sector, processors, and research institutes, together to coordinate their interests in practising ecosystem service and mangrove-shrimp farming. CfM worked as a middle organisation to solve conflicts of mangrove management between FMB and farmers. In 2012, CfM launched an eight-

[11] The national afforestation policy includes the Five Million Hectares Reforestation Project (1998-2010), Forestry Development Strategy (2006-2020), National Target Program (2016-2020), and Forestry Development Strategy (2021-2030) (Triệu et al., 2020).

Figure 26 FMB forest map.

The black line shows the boundary of land property. The light orange colour is young mangrove forests and the dark orange colour is mature mangrove forests. The small long strips of land are farmers' shrimp ponds. The large dark orange part in the coastal area (bottom right) is the conservation area owned by the government.

Source: Author

year-long project on mangrove restoration, payment for forest ecosystem services, and sustainable livelihood and aquaculture practices. CfM visited farmers, governments, and companies individually to know their opinions on shrimp farming and mangrove preservation and restoration. They held training courses for farmers, letting them know that the ecosystem service of mangroves can provide feed for shrimp and lower the water temperature. The Cà Mau Provincial People's Committee supported mangrove-shrimp farming and the payment for ecosystem services through law and policies.[12] With the policy, Minh Phú company, a Vietnamese shrimp processing company, was willing to pay a higher price for organic shrimp, so farmers in Nhưng Miên were under contract. The local government and farmers recognised the ecosystem service of mangroves and supported mangrove preservation and organic shrimp farming.

[12] Decision No.111/QĐ-UBND and No. 156/2018/ND-CP

5.1.2 *Improved extensive shrimp farming with governmental institutes*

Improved extensive shrimp farming has developed from farmers' adaptation strategies and governmental projects. Due to climate change, farmlands in coastal provinces are becoming highly salinised. Farmers utilise their lands with their experiences, infrastructures, and natural hydrological regimes to develop improved extensive shrimp farming as an adaptation strategy (Marks, 2010). This model is polyculture farming and has many combinations, such as rice shrimp (rotational or simultaneous), shrimp-fish, and shrimp-salt.

Improved extensive shrimp farming was also supported by governmental policies and several international cooperation projects to develop better farming skills and integrate farmers and cooperatives. In 2000, the Vietnamese government announced a policy (policy number: 09/2000/NQ-CP ngày 15/6/2000) on the transformation of economic structure and the consumption of agricultural products, encouraging the development of shrimp aquaculture. Thus, some local governments changed rice farms into the rice-shrimp model. In 2010, the Nam Sông Hậu Research Institute of Aquaculture Branch published a manual about the farming practices of rice-shrimp farming.[13] The manual showed how rice-shrimp farming works with the seasonal change of salinity (freshwater and saline water). The governmental institutes also tried to upgrade the agriculture organisation to increase the economic value of the industry. In 2019, the GEF Small Grants Programme released a report, *Promoting sustainable value chains in rice-shrimp*, to increase rice and shrimp value chains by organising farmers into cooperatives to participate in the market (Hội Thủy sản tỉnh Bạc Liêu,

[13] The participants in this project include the Research Institute of Aquaculture Nam Sông Hậu Branch, Cần Thơ university, Australian Centre for International Agricultural Research, University of New South Wales, Griffith University, and Charles Sturt University.

2019).[14]

5.1.3 Intensive shrimp farming in a Khmer community

Due to climate change and saline water intrusion, the local government encouraged minor ethnic farmers in Bạc Liêu to shift their rice fields or salt farm to black tiger shrimp or brine shrimp (artemia) ponds as a poverty alleviation project. This research investigated the model of intensive shrimp farming in a Khmer minority community in Bạc Liêu. With my Taiwanese friend's introduction, I met Phương, a Khmer Vietnamese woman who married a Taiwanese farmer and immigrated to Taiwan for around ten years through a profit-pursuing marriage agent. Phương and her family are Khmer, and her family is doing commercial shrimp farming in Gia Nghĩa (pseudonym), in the Mekong Delta. Gia Nghĩa is a minority (dân tọc) community, where 73% of the population are Khmer, and the rest is Kinh (Vietnamese major ethnic group) and Chinese.

However, because of shrimp disease, shrimp farming did not always enrich farmers and investors, such as local communist party members, court prosecutors, and other civil servants, but sometimes caused them to be in massive debt to banks (Phương Trang, 2010). In December 2019, it was my first meeting with Phương in Taiwan to explain my purpose of visiting her parents in the Mekong Delta. Phương asked me why I wanted to study shrimp aquaculture. I answered that shrimp farming is very interesting. She responded that "*when you breed shrimp by yourself, you will have lots of pressure, and that is not fun and interesting*." Due to shrimp disease, Thành, her father, just lost all of his shrimp and had more economic burdens. I felt very embarrassed about my answer. As a researcher, shrimp farming is a fascinating research topic; but for shrimp farmers, it is their livelihood, and an outbreak of disease affects farmers' income

[14] The participants in this project include Bạc Liêu Association of Seafood Exporters and Producers, Huyện Phướng Long- Hồng Dân People's Committee, National Agriculture Extension Centre, Global Environment Facility (GEF), United Nations Development Programme.

significantly. Intensive shrimp farming provides an opportunity for farmers to have a better income but also generates the risk of shrimp disease and personal debt.

5.1.4 Super-intensive shrimp farming with a Taiwanese shrimp processing company

Super-intensive shrimp farming aims to increase shrimp output and decrease the risk of shrimp disease to scale up the business. In March 2020, I had afternoon tea with Ming-Yi, his office manager, and a technician in a five-star hotel in Hồ Chí Minh City. Ming-Yi planned to expand his super-intensive shrimp ponds from 10 hectares to 100 hectares by either buying or renting lands from farmers. The local government could help him obtain 90-hectare of land in the future. Compared to other small farms, owners of large farms have better links to the state bureaucracy for acquiring support and information (Belton et al., 2011). For the expansion, Ming-Yi cooperated with Dr Anh and Ching-Shin, a Chinese Malaysian businessman who has been working with Ming-Yi for more than ten years, to secure the required number of larvae from hatcheries. In June 2020, Ming-Yi already constructed 40 more shrimp ponds, released 100 million postlarvae into ponds, and estimated a harvest of 200 tons of whiteleg shrimp in September 2020. Ming-Yi believed that super-intensive shrimp farming was a biosecure model to boost his business.

In addition, some Vietnamese farmers were also able to upgrade from intensive shrimp farming to super-intensive farming. Once Hùng, a Vietnamese sales manager of a Taiwanese shrimp feed company in Bạc Liêu, brought me to visit Hải, a Vietnamese farmer breeding shrimp for 20 years. Hải has been buying shrimp feed from Charoen Pokphand Group (CP), a famous Thai shrimp feed company, for a very long time. In 2017, CP brought him to visit other super-intensive shrimp ponds and encouraged him to adopt this model. After the visiting tour, Hải reformed his shrimp pond from land ponds into plastic ponds with automatic feeding machines and water pipelines. Unlike

Ming-Yi, a capitalist who grew shrimp on his farms, CP took a different route that bypassed the growing period, the high-risk segment in the commodity chain (Goss et al., 2001). Furthermore, CP increased its sales of shrimp feed by helping farmers to adopt super-intensive shrimp farming, which requires more input from shrimp feed. After adopting this model, he received many awards from CP, Cần Thơ University, and the Bến Tre government as a distinguished farmer. Companies and their managers play a key role in enrolling farmers into market economies, but farmers also have aspirations to involve in investment projects (cf. Ouma, 2015: 101-107).

The class position of farmers in super-intensive shrimp farming is blurry and often crosses other class positions. After the interview with Hải , Hùng asked me how I would introduce Hải to my Taiwanese friends: a farmer or a boss (ông chủ). I answered that Hải is both farmer and a small capitalist. Hải was a farmer but must be richer than most farmers since not many farmers, like Thành, had enough money to invest in this industrial model. Nevertheless, Hải hired four workers to prepare shrimp feed and manage the shrimp ponds throughout the year. The experience of Hải blurred the boundary of classes between farmers and small capitalists. On another occasion, Hùng told me that the Vietnamese farmers also chat, share shrimp prices on social media, such as Facebook, Zalo, and LINE, and drink coffee in the city centre of Bạc Liêu. We went to the city centre and there met an urban elite farmer in a café. The farmer held a bachelor's degree in communication studies and decided to breed shrimp 3-4 years ago because of the huge profits. He also hired workers for his shrimp ponds. Even though shrimp farming is a risky business, it still draws many foreign companies, urban entrepreneurial elites, and local farmers to invest or upgrade their ponds into super-intensive shrimp farming to boost productivity and reduce the risk of shrimp disease.

This section has depicted the development of shrimp farming in the Mekong Delta on a regional scale across four kinds of shrimp farming. It showed that shrimp aquaculture was mobilised for economic development, poverty alleviation, and climate change adaptation. The capitalist mode of shrimp farming has been widely and deeply expanding in the Mekong Delta through shrimp monoculture, including intensive and super-intensive shrimp farming. In some areas in the Mekong Delta, the development of shrimp farming was also confined by land-use plans and state regulations, so that farmers practise shrimp polyculture, such as integrated mangrove-shrimp farming and improved extensive shrimp farming. This confinement stimulated the development of organic shrimp as a kind of commodity transformation in the Mekong Delta (cf. Banoub et al., 2020).

5.2 Comparing hydro-social lives in four kinds of shrimp farming

This section focuses on hydro-social lives of four types of shrimp farms, where farmers and companies grow shrimp into the size of a marketable product. To achieve this goal, farmers and companies organise their hydro-social lives to manage water-shrimp-humans-delta relations by constructing shrimp domus, managing shrimp diseases, and arranging the everyday life of farmers, workers, and capitalists. At the same time, each kind of shrimp farming presents a distinctive set of agrarian, technical, and environmental changes (Table 7).

By comparing hydro-social lives in four kinds of shrimp farming, this section makes three arguments. First, ecological conditions of shrimp production are underpinned yet also impeded by the deltaic environment. For example, the spatiality of the delta — such as the distribution of freshwater and saline water — influences husbandry practices and the use of infrastructure. The temporalities of commercial shrimp farming, precisely the growth rate of shrimp and the circuit of capital, are related to the temporalities of nature, such as the daily and monthly rhythms of tides, seasonal

Table 7 Hydro-social lives in four kinds of shrimp farming

Type	Water-shrimp-humans-delta relations	Agrarian, technical, and environmental changes
Integrated mangrove-shrimp farming	*Water:* ■ Saline water abundance but poor water quality ■ Exchanging water regularly or occasionally *Shrimp and other species:* ■ Organic black tiger shrimp, other shrimp species, fish, and crab ■ Mangrove forest as ecosystem service ■ Creating natural food chains ■ Shrimp diseases as a natural phenomenon *Delta:* ■ Growing shrimp with the rhythm of the delta	*Agrarian change:* ■ Afforestation policy and contract: farmers learn how to plant mangrove forest ■ Working in cities during the production time *Technical change:* ■ Learning organic shrimp farming ■ Using the water quality monitoring App ■ The installation of hygiene toilets *Environmental change:* ■ Mangrove forest conservation
Improved extensive shrimp farming	*Water:* ■ The seasonal change of freshwater and saline water ■ Managing soil quality ■ The rotation of rice-shrimp changes water quality and the environment to reduce the risk *Shrimp and other species:* ■ Growing rice and shrimp rotationally ■ Breeding black tiger shrimp in the dry season and giant freshwater shrimp in the rain season	*Agrarian change:* ■ Organising rice-shrimp production through developing cooperatives *Technical change:* ■ The manual and training in rice-shrimp farming *Environmental change:* ■ Improved extensive shrimp farming as a kind of climate change adaptation

	■ Creating natural food chains ■ Shrimp diseases is a natural phenomenon *Delta:* ■ Using canal and sluice gates to manage the seasonal change of water quantity and quality ■ The construction of hydraulic infrastructure to shape the water provision	
Intensive shrimp farming	*Water:* ■ Sterilising water ■ Managing soil quality and removing sludges ■ Using ventilators to increase dissolved oxygen *Shrimp and other species:* ■ Whiteleg shrimp (monoculture) ■ Using shrimp feed, probiotics, and antibiotics ■ Shrimp diseases outbreak easily and cause huge economic loss *Delta:* ■ The influence of wastewater from upstream	*Agrarian change:* ■ Shrimp farming is a double-edged sword for poverty alleviation ■ Shrimp economies are supported by kinship, community ties, and international remittance to tackle the impact of shrimp diseases *Technical Change:* ■ Using shrimp feed shapes the everyday life of farmers *Environmental change:* ■ The higher risk of shrimp disease ■ Discharging wastewater into rivers and canals

Super-intensive shrimp farming	*Water:* ■ Sterilising water and using probiotics and antibiotics ■ Water and soil are separated by plastic mats ■ Using ventilators and pipelines to increase dissolved oxygen ■ Exchanging water every day *Shrimp and other species:* ■ Whiteleg shrimp (monoculture) ■ Using shrimp feed and probiotics ■ Shrimp diseases are highly excluded through shrimp domus *Delta:* ■ Shrimp domus is used to overcome the natural obstacles in the delta ■ The influence of wastewater from upstream	*Agrarian change:* ■ The investment from urban elites and foreign capitalists ■ Some farmers upgrade their ponds into super-intensive shrimp farms ■ Hiring workers and operating the living system *Technical change:* ■ Increasing the shrimp density to boost the productivity ■ Accelerating the growth rate of shrimp, reducing the breeding period ■ Better biosecurity practices *Environmental change:* ■ Discharging wastewater into rivers and canals

changes, and the variation of wetness and salinity in the delta. Second, growing shrimp requires aligning the lives of farmers and workers with the life cycle of shrimp (also see Blanchette, 2020). Different kinds of shrimp farming require certain forms of husbandry practice, involving both capitalist and more-than-capitalist relations to breed shrimp, maintain water ecologies, and prevent shrimp diseases (also see Lien, 2015: 126). Third, the outbreak of shrimp disease indicates economic and ecological contradictions within hydro-social lives. Breeding more shrimp in ponds increases the risk of shrimp disease, which causes uneven impacts on different types of farmers.

5.2.1 *Forest conservation and organic shrimps in mangrove-shrimp farming*

Integrated mangrove-shrimp farming uses the mangrove ecosystem to breed shrimp naturally (thiên nhiên) and ecologically (Figure 27). Farmers, FMBs, and CfM manage (1) the mangroves and shrimp ponds on land, (2) water quality, and (3) water ecologies to breed the organic black tiger shrimp.

Figure 27 Integrated mangrove-shrimp farming

Source: Author

First, the land is compartmentalised into mangrove forests and shrimp ponds. The reforestation policy and the leased forest contract set the number of reforestation areas, regulated the area of forestry and shrimp pond, and reformed the human-mangrove-shrimp relationship. According to the contract, Nhưng Miên FMB has the duty of training farmers on how to plant and care for mangroves. Farmers received planting fees in the first year only. Civil servants from FMB and forestry police officers (kiểm lâm) check the mangrove forest regularly to make sure farmers have properly maintained their forests. In Cà Mau peninsula, the leased forest contract allowed farmers to earn profits in two ways: logging mangroves and ecological shrimp farming. After receiving permission from Nhưng Miên FMB, farmers can log the mangroves in the 12th-15th years. The profit from logging was shared by farmers and FMBs. After a contract has expired, farmers must sign a new contract and replant mangroves. FMBs emphasised how the ecosystem service of mangroves brings benefits to shrimps and other creatures. For shrimp farmers, planting trees was not difficult, but it was quite annoying to have too many leaves on the shrimp ponds, which need to be cleaned up every 20 days because decomposing leaves might cause the shrimp pond to lack dissolved oxygen. The regulation of mangrove forests and shrimp ponds sets up the relation of the land-mangrove-shrimp pond.

Second, farmers in Cà Mau did not lack saline water but rather proper water quality and ecologies to produce organic shrimp. Some farmers received organic certification from Naturland and Euro with the help of CfM to tackle the low water quality. CfM and FMB held a series of workshops to share farming practices to meet the requirement of organic certification. There were three aspects of water management that needed to be improved: pond water management, daily wastewater management from households, and wastewater from upstream. First, during the breeding period, some farmers exchanged water every two months or never exchange water, causing water quality to deteriorate in ways not good for organic shrimp farming. Other farmers exchanged their water two times per month, which CfM encouraged farmers to follow. Second, CfM subsidised some farmers to install hygiene toilets to collect domestic wastewater. Building hygiene toilets is crucial to prevent water quality and ecology from being polluted by domestic wastewater. After seeing the advantages of installing hygiene toilets, other farmers also installed hygiene toilets in their homes. Third, the wastewater from upstream would influence the organic shrimp farming downstream. The timing of exchanging water is important. They can either evaluate water quality from the colour of river water, the timing of the high tide or use Tôm rùng, a water quality monitoring App created by CfM. During the high tide, the clear seawater flows into the delta, which means that water is not polluted by intensive shrimp farming upstream. CfM in workshops trained farmers to meet the standard of organic shrimp, such as using hygiene toilets and new husbandry practices, to manage water quality and ecology, and to enter the Global North market (also see Ouma, 2015: 146).

Third, farmers created water ecologies that were based on natural food chains, had lower labour requirements and that, as a result, freed themselves from the land. In the 7th or 8th month of the Lunar calendar, farmers bought black tiger shrimp or crab postlarvae from hatcheries and released them into shrimp ponds. Other kinds of shrimp, crab, and fish flow from canals into shrimp ponds. Farmers do not feed shrimp with commercial shrimp feed but with algae, plankton, and other natural food from river water. Compared with intensive and super-intensive shrimp farmers, farmers have more free time and are less constrained by the feed companies. The risk of disease outbreaks is lower since shrimp density was around 1-6 black tiger shrimps / m^2. Even when shrimp become ill, farmers do not take any action and instead understand it as a normal phenomenon. Thus, many farmers can work in Cà Mau city centre or local towns while also owning and working the shrimp ponds. For instance, Trúc, a mangrove-shrimp farmer and a relative of my Vietnamese teacher, worked as a financial consultant in a life insurance company in Cà Mau city centre. In another example, Dũng worked for CfM, but shared his mangrove-shrimp ponds with his brothers. Dũng was born and grew up in Northern Vietnam, but his family migrated to Thài Bình (pseudonym), which is a remote village in Cà Mau. It took us 2 hours and a half to travel from Cà Mau city centre to a local market and transferred to his shrimp pond by water taxi at the local market. Residents in Thài Bình commute to neighbours and local markets by private boats or water taxis (Figure 28). Thus, poaching rarely happened since it was impossible to harvest shrimp and transport them outside. Farmers did not look after shrimp at night. Most of the people left villages and worked in cities and towns.

Figure 28 The riverbank of Dũng's mangrove shrimp ponds: boats are the main transportation in Thài Bình.

Source: Author

5.2.2 *Rotational polyculture in the improved extensive shrimp farming*

In improved extensive shrimp farming, farmers need to manage (1) water quality, (2) soil quality, and (3) ecology (crops, shrimp, and bacteria) in different seasons. The improved extensive shrimp farming shows how the seasonal change of freshwater and saline water shapes the farming practice and creates a distinctive water ecology.

First, farmers meticulously managed the variation of water salinity through hydraulic infrastructures to cope with seasonal changes. Farmers usually breed black tiger shrimp in the dry season (higher water salinity, around 5-25‰); and grow rice and breed giant freshwater shrimp in the rainy season (lower water salinity, around 2-3‰). In the dry season, canal managers opened sluice gates to let saline water flow into canals. Farmers could pump saline water into their farmland to breed black tiger shrimp. In the first 30 days of pouring postlarvae, farmers usually kept them in a small zone with nets to prevent them from being eaten by fish. During the rainy season, canal managers closed sluice gates to prevent freshwater from saline water intrusion. Canals became small reservoirs to keep freshwater since rivers in coastal provinces were already salinised, and irrigating land with river water makes the land saltier. Nevertheless, farmers pump water from irrigation canals, where water was from rainfall but not rivers from upstream, which were already captured by dams.

Second, the soil is not only a container for water and shrimp but also the growing medium for rice. During the dry season, farmers loosened the soil after shrimp farming to let lime and freshwater infiltrate deeper into the soil to wash the salt away. Farmers waited for the rain to wash the salt away (rửa mặn) for around 30 days (Figure 29). Farmers discharged water three times to complete the practice of desalinisation. If the rain is heavier and more frequent in the rainy season, it will take less time to desalinse lands.

Third, this saline-freshwater interface creates two sets of multi-species relationships: saline water-shrimp-farmers in the dry season and freshwater-rice-shrimp-farmers in the rainy season. The seasonal change in water quality and ecology is a critical factor in reshaping multi-species relationships and decreasing the risk of shrimp disease. During the rainy season, farmers grew certain varieties of salt-tolerant

Figure 29 Preparing land for growing rice in July 2020
Source: Author

rice (water salinity below 5‰), such as Cà Mau 1, Cà Mau 2, Một bụi đỏ lùn/ Một bụi lùn and other varieties of fragrant rice, in the interface of freshwater and saline water. These varieties grow faster (95-105 days or 140-145 days) and are more tolerant to climate change. However, farmers do not like to grow salt-tolerant rice because these varieties are not delicious, and the price is lower. Farmers usually kept some space between rice for giant freshwater shrimps, which reduces the density of rice and the risk of rice diseases. The sludge of shrimp farming produced in the dry season was used as a natural fertiliser for rice farming. Furthermore, the rice-shrimp rotation could reduce the risk of shrimp disease by using freshwater to suppress the population of *Vibrio vulnificus* during the rainy season. *Vibrio vulnificus* presents in marine environments, such as brackish ponds and coastal areas, and is the main pathogen of shrimp disease. The seasonal change of freshwater and saline water and the rotation of rice and shrimp farming let the land rest and created a more biosecure environment for rice and shrimp. Rice shrimp farming builds a natural food chain rather than using any commercial shrimp feed, which helps farmers reduce the cost of shrimp production and not to have the risk of being indebted.

Seasonal rainfall in the Mekong Delta is not stable, so the Vietnamese government is building regional hydraulic infrastructure to distribute freshwater to coastal provinces. The rainy season came later in 2020, owing to climate change, and farmers were facing serious droughts or less rainfall to wash the salt away (Sỹ Hào, 2020). In this circumstance, a governmental hydraulic engineer explained that they could only predict the timing of the rainy season next year and inform farmers to save water earlier. Although groundwater in the Mekong Delta was mostly freshwater, farmers were not allowed to extract groundwater to do farming, which would cause land subsidence. The Vietnamese government is building the Cái Lớn - Cái Bé hydraulic system (hệ thống thủy lợi Cái Lớn - Cái Bé) in Kiên Giang, which will transport freshwater to Cà Mau to solve the problem of water scarcity and support agriculture production.

5.2.3 Shrimp diseases and security strategies in intensive shrimp farming

Intensive shrimp farming produces more shrimp in ponds but also generates a higher risk of shrimp disease. Farmers arrange (1) land and soil quality, (2) water quality and water ecology, and (3) husbandry practices to compose the shrimp domus and care for shrimp in their everyday lives. The hydro-social life of intensive shrimp farming is intertwined with kinship and community ties. For example, Thành has four daughters: Thu, Hòa, Phương, and Lộc (in the order of age). Except for Phương, now living in Taiwan, the other three daughters and their husbands are doing intensive shrimp farming in the same or nearby villages. Thành introduced me to all his daughters and their husbands. Their family stories about labour and marriage migration and international remittance showed how kinship was mobilised to tackle the economic loss from shrimp diseases.

First, the land is the container for water and shrimp, and the soil is the quality of the container. Farmers managed the shrimp pond and let the soil rest before the breeding season. They discharged water out from their ponds, removed sludge from last shrimp farming, let the sunlight shine on this land for a week, and used lime to ameliorate salinity and the pH value of the soil. The sludge usually contained shrimp shells, shrimp excrement, and shrimp feed residues, which increased the level of ammonia. The pH value of soil would influence the pH value of water and water ecologies, which affect the health of shrimp. Thus, land and soil preparation involved letting the soil rest to reduce the risk of shrimp disease.

Second, water is prepared, and water ecology is managed by farmers. Farmers pumped water from canals and sterilised it for 10-20 days by adding chlorine. After that, they sprayed tea seeds to kill fish since water from canals contains fish and other shrimp predators (Figure 30). Farmers also sprayed probiotics and minerals to increase the population of good germs, such as photosynthetic bacteria and aerobic bacteria. Thành explained that good water should look like the colour of seawater since it contains good algae and fewer river sediments. Farmers bought shrimp postlarvae either from local hatcheries in the Mekong Delta or hatcheries in Ninh Thuận, central Vietnam.

Third, as for husbandry practices, farmers are confined to their lands to feed and care for shrimp. Their working time needs to fit with the production time. Farmers fed shrimp commercial shrimp pellets two or three times (morning, noon, and evening) per day, depending on the size of the shrimp. Farmers used a sampler to observe the remnant of shrimp feed in the shrimp pond to decide the timing of the next meal (Figure 31). The sampler made shrimp ponds like aquariums that can be transparent and calculated (Callon, 2008: 337). In the first two months, farmers only went to shrimp ponds during the feeding time and could work for others in their free time. In the first

Figure 30 Nam sprayed tee seed before pouring postlarvae
Source: Author

Figure 31 A simpler for observing shrimp and the remnant of shrimp feed
Source: Author

two breeding months, Hoàng (Lộc's husband) worked for others on their farmland or construction sites near the village to earn more money. His wife helped him feed shrimp at noon. Before feeding shrimp, farmers will turn on the ventilators to provide dissolved oxygen. Some farmers, like Thành, used diesel generators to operate ventilators; others richer farmers, like Nam and Thu having a better standard of living, used electrically-powered generators attached to their private electric cables from their houses to shrimp ponds. When shrimp grew bigger into the harvestable size, farmers usually stayed in their private huts beside their ponds to guard their shrimp. In the nighttime, Thành and Thủy always slept in their improvised hut beside shrimp ponds to prevent poaching (Figure 32). Some neighbours kept dogs as a safeguard. In Nam and Thu's village, they lived very close to their relatives, so that they usually took rotation with relatives to look after shrimp at night. While looking after shrimps, Nam only went back home for meals and mostly stayed and slept in his hut beside the shrimp ponds.[15] In Vietnam, the labour demand in small-scale agriculture and aquaculture is mainly met through kinship (Belton et al., 2011; Porter, 2019). However, it does not mean that farmers cannot be free from their lands: farmers simply breed fewer shrimp when they plan to travel away from the farm for a while. For example, Thành inherited five shrimp ponds from his parents and purchased another five ponds from farmers. In my first visit, Thành only bred shrimp in one pond because Thành and Thủy planned to visit Phương and bring their grandkid back to Taiwan. However, due to the COVID-19 pandemic, the plan was cancelled. In intensive shrimp farming, the everyday life of farmers is synchronised with the life cycle of shrimp.

Although managing shrimp ponds and caring for shrimp carefully, there were chances of getting infected, which caused a huge economic impact on farmers. If shrimps have symptoms, farmers, including Thành, might use antibiotics to control the disease. The outbreak of shrimp diseases might result from wider water management in the delta. Due to the lack of a well-designed water system, farmers always directly discharged the wastewater into canals and rivers without any treatment. Thành thought

[15] Nam used to grow rice but changed to breed shrimp because of higher income. He has been breeding shrimp for 20 years and self-learned shrimp farming. Nam told me that the shifting from growing rice to breeding shrimp was not that difficult. Nam could manage 10-12 shrimp ponds at the same time, which is an impressive achievement. Thành can only take care of 5-6 shrimp ponds per time.

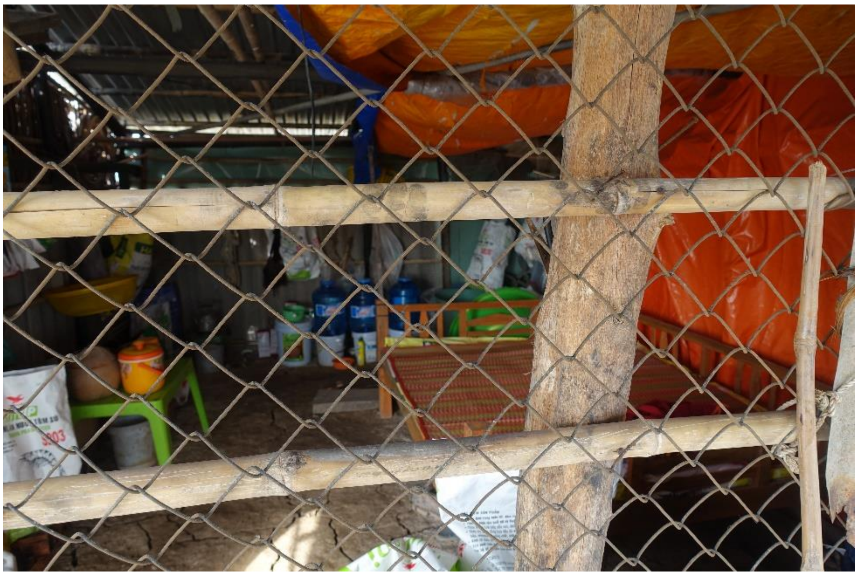


Figure 32 Thành's hut next to his shrimp ponds

Source: Author

that the death of shrimp is caused by the wastewater from the pond of his nephew.[16]

In intensive shrimp farming, contradictions between shrimp farming and shrimp diseases are often mitigated by crop income, waged work, and international family remittances. From the experience of Thành and his family, there were four strategies for securing the livelihood and mitigating the impact of shrimp diseases: (1) selling ill shrimp before they die, (2) planting other crops, (3) working in cities, and (4) international remittance from Taiwan. First, when Thành saw two shrimps had died in his pond, he sold all the shrimp out on the same day to secure his income. If farmers want to get a higher price, buyers will collect some shrimp samples and bring them to a laboratory to check whether they contain antibiotics. It usually took a day to get the result. However, if farmers are afraid that shrimp might die soon, they would skip the testing process and sell at a lower price. It usually takes 3-4 hours to harvest all the shrimp. Although the price was lower, Thành at least earned some money. Second,

[16] Similarly, due to the proximity of intensive shrimp farming and rice farming, the overflow of saline water influences rice farms, which makes rice paddy dead since these two types of farming require different kinds of water.

Thành had two other farmlands for longan trees and pumpkin as an extra income to mitigate the economic loss from shrimp diseases (Figure 33). Thành planted more longan trees on his lands. However, due to the salinisation, he cannot use the salty water from the canal to ameliorate alkaline soil but waited for freshwater from rainfall. Third, when the price of shrimp is low or their shrimp die, Hoàng and Lộc move to Hồ Chí Minh City to work in factories or forest farms.[17] Their two daughters stayed on the farm and were cared for by Thành and Thủy. Although Hoàng felt frustrated by shrimp diseases, he still preferred living with his family and breeding shrimp rather than working in a factory in Hồ Chí Minh city. Due to COVID-19, they moved back from Hồ Chí Minh City to Thành's home and took over Thành's shrimp ponds to do shrimp farming. Young farmers often shifted their class position between farmer and worker. Fourth, Phương remitted $ 200 USD per month and extra money from Taiwan to Thành to compensate the cost of babysitting Phương's child and subsidising the expense of shrimp farming. Phương occasionally sent and subsidised some money to her siblings to buy larvae from hatcheries. This remittance showed that the small-scale and intimate forms of direct resource transfer supported shrimp economies in the Mekong Delta (cf. Faier, 2013). These four strategies reflect how shrimp economies do not operate in a vacuum but are associated with other forms of economies and the mobilisation of more-than-capitalist relations.

Transnational remittance as a security strategy reflects how rural Vietnam links to other countries, which shapes their family relations, local industries, and rural landscape. Due to socio-demographic changes in Asian countries, women have received higher education and better income, and Taiwanese and Korean rural men with a

[17] Before marrying Hoàng, Lộc was a migrant factory worker in Malaysia but not satisfied with her job and moved back to Vietnam.

Figure 33 The harvesting of longan

Source: Author

disadvantaged socio-economic status in the domestic marriage market tend to seek foreign brides (Bélanger and Wang, 2012), just like Japanese rural men have married with Filipino women (Faier, 2009). Although international marriage between Taiwan and Vietnam was mostly facilitated by profit-pursuing marriage agents (Wang and Chang, 2002), it also created a kind of transnationalism from below, coming from individuals in low social strata (Bélanger and Wang, 2012). These marriages were not just about frustration and limitations but also included pleasures and possibilities, which form a different transnational world (Faier, 2009: 4). For example, while I was interviewing in a Vietnamese shrimp medicine shop, the shopkeeper was so happy to know I am Taiwanese and told me that her younger sister married a Taiwanese guy. In 2018, her younger sister invested in a giant freshwater shrimp hatchery in Bạc Liêu and let her relatives run the business. Under the gendered and patriarchal structure, if Vietnamese migrant spouses have a stable salary or money given by their husband and his family, they would send remittance to their natal families either supporting their livelihood, building new houses, or developing a new business, including the shrimp industry (Bélanger et al., 2011; Faier, 2013; Chang, 2019). The transnational family kinship is a kind of more-than-capitalist relation supporting shrimp economies.

5.2.4 *Industrial upgrading and capital accumulation in super-intensive shrimp farming*

The new super-intensive shrimp farming increases shrimp density, decreases the risk of shrimp disease, and accelerates the cycle of production. To achieve this high productivity and biosecurity model, the super-intensive model of shrimp farming (1) creates a distinctive container to detach water from the soil, (2) manages water quality, waste, and water ecology with biosecurity measures, and (3) recruits workers to breed shrimp. Super-intensive shrimp farming bypasses natural barriers and deepens the capitalist mode of production in the growing sites.

In November 2019, I visited Ming-Yi's super-intensive shrimp farming ponds in Bến Tre with potential Taiwanese investors. In the last few years, Ming-Yi spent most of his time in his processing factory and had not visited his shrimp ponds for almost ten years. Ming-Yi's shrimp ponds are located between the main canal and Ba Lai river. In the early morning, Ming-Yi brought us to his shrimp ponds, but road maintenance meant we needed to walk a short distance. Because of the broken road, the Vietnamese driver could not drive us to the newest shrimp ponds, and we needed to walk there. While walking on the embankment between the shrimp ponds, Ming-Yi told us that he spent money to broaden the embarkment and built up this asphalt road to transport the shrimp from the ponds to his factory. However, the government demolished the road because Ming-Yi is a Taiwanese and cannot own the land but can only rent it from the Vietnamese. The boundary to each plot of land should not be modified. After a 10-minute walk, we saw most of the shrimp ponds were unused, and some workers were building round experimental shrimp ponds with plastic mats and pipelines within the old soil shrimp ponds (Figure 34).

Figure 34 Super-intensive shrimp ponds

Source: Author

There are three distinguishing features of hydro-social life in super-intensive shrimp economies. First, Ming-Yi created a safer and controllable container by levelling land, constructing ponds with steel in a cylinder shape, and covering ponds with plastic mats. The plastic mat was used for detaching water from the soil. The soil was viewed as a potential pollutant source with bacteria, viruses, and chemical elements that would influence the pH value of water. The plastic mat separated water from the soil, which was easier to control water quality. In other forms of shrimp farming, biosecurity concerns mean sludge and the excrement and shell of shrimp in the soil must be removed, and the soil needs to rest before the next shrimp farming. Yet, super-intensive shrimp can overcome this natural barrier and keep breeding shrimp over the year with biosecurity management.

Second, water management is key for enhancing the density of the shrimp population and reducing risk. Water was pumped from rivers and canals and sterilised in water reservoirs. Ming-Yi installed water pipelines from water reservoirs to each shrimp pond for filling water daily. Water salinity should be higher than 15‰. The abnormal rainfall in the dry season caused by climate change would influence the level of water salinity, which brought another uncertainty to super-intensive shrimp farming. Thus, farmers, like Hải, and companies usually kept some space to allow for drastic decreases in water salinity. Farmers created a hole for wastewater discharge at the centre of shrimp ponds connected to a buried pipe (Figure 35). With this design, they can discharge wastewater when water quality becomes worse, such as ammonia is above 0.03 mg/L. Farmers can then pump sterilised water from their reservoirs any time in the day. In addition, they installed protein skimmers on each pond to remove broken down, uneaten foods, shrimp waste, and suspended particulates to maintain water quality and reduce the risk of shrimp disease (Figure 36). They provided dissolved oxygen from above by ventilators and from below by plastic pipelines attached with cement to keep it submerged to increase shrimp density (up to 260-300 shrimps/m^2). The ventilators on the water surface shaped the water flow and the flow of shrimp shells and waste. The ventilators work better with the cylinder-shaped pond than with the traditional rectangular one. The rectangular one has four dead zones at each corner, where waste accumulates and is hard to remove. All these devices were connected to electric infrastructure or air pumps, privately invested in by Ming-Yi. This model requires significant capital investment, and only some farmers can afford the cost. Hùng told me that even if some farmers had the capital to upgrade their shrimp ponds into super-intensive shrimp ponds, they did not design the water inlet or outlet in the correct places, which was a waste of money. In his free time, Hùng helped farmers design their super-intensive shrimp ponds, such as arranging their water ponds, shrimp ponds, pipeline and electricity lines, and wastewater treatment (Figure 37). Currently, there are some consulting companies in the Mekong Delta or Hồ Chí Minh City helping farmers to design their super-intensive shrimp ponds with an estimated budget.

Figure 35 Shrimp ponds, pipelines, and wastewater
Source: Author

Figure 36 A protein skimmer for a super-intensive shrimp pond
Source: Author

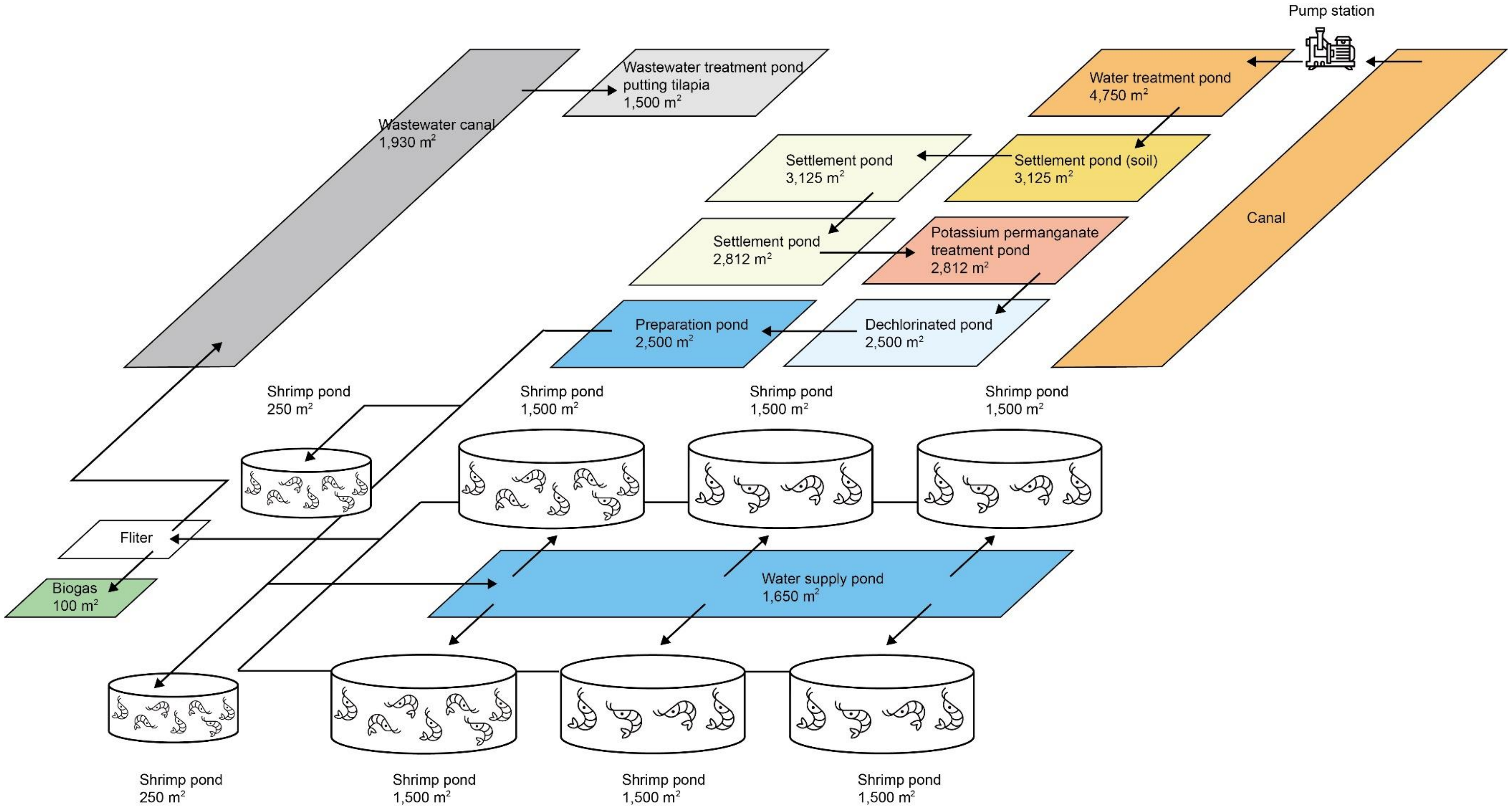


Figure 37 The layout of a super-intensive shrimp farm

Source: Unpublished manuscript from Hùng; images from (Chanut is Industries, 2021; Nareerat Jaikaew, 2021)

Third, capitalists recruited labourers to feed and care for shrimp and shrimp ponds, which frees capitalists from shrimp ponds but binds labour to the land. In shrimp farms, both Taiwanese and Vietnamese capitalist farmers tend to hire workers without any shrimp farming experience. One day, I was in a business meeting with Ming-Yi and Dr Anh. Dr Anh suggested Ming-Yi not hire residents or experienced farmers because they might steal shrimp feed or have strong opinions on shrimp farming. The installation of an automatic feeding machine is a solution since workers need to log in the number of shrimp feed and cannot steal the feed. Ming-Yi explained that employing unfit managers and workers was one of the main reasons that he could not manage his shrimp ponds properly in the last twenty years. This conversation reflected that a foreign capitalist and an urban elite viewed Vietnamese farmers and residents as undisciplined workers with a class and racial stereotype. Furthermore, as a capitalist of a huge foreign company, Ming-Yi requires more dedicated labour management to settle foreign capital in the local context. When Taiwanese capital enters Vietnam, it needs to reorganise its production networks, such as labour management in gender, race, and class dimensions (Wang, 2019). Like other Taiwanese manufacturing in Vietnam, in his processing factory and shrimp ponds, he hired Taiwanese as top managers, Chinese Vietnamese as middle managers and translators, and Kinh and other minority Vietnamese as manual workers. Ming-Yi recruited Wei-Ting, a Taiwanese shrimp farming technician, to improve shrimp pond management. Even though Wei-Ting was an expert in breeding shrimps in Indonesia, China, Honduras, and Ecuador, he still faced difficulties in managing Vietnamese workers. In fact, Ming-Yi's Vietnamese workers are still mostly farmers from local areas and have their private shrimp ponds. Once, I talked to a female worker in Vietnamese; she told me that she is a local farmer and her family is also breeding shrimp near Ming-Yi's shrimp farm. They had just prepared the water and would buy larvae very soon. She and her husband took care of their shrimp together but worked for others in their spare time to earn extra income. Some of the migrant workers from other provinces lived in the dormitory on Ming-Yi's shrimp farm, so-called the live-in system, to care for shrimp 24 hours (Huang, 2015). Like colonial plantations (Li, 2014), the live-in system in super-intensive shrimp farming made migrant workers highly dependent on aquaculture and easily disciplined. Each migrant worker was assigned to a certain amount of shrimp ponds and took care of the shrimp 24 hours, such as feeding them from morning to evening. Their lives were bound with shrimp lives for capitalists under hydro-social life for super-intensive shrimp farming.

In super-intensive shrimp farming, capitalists practised biosecurity to secure their profits by shortening the breeding time of shrimp. Super-intensive shrimp farming has two production stages to reduce the fatality rate of shrimp in the early stage. In the first stage, farmers keep 3,000-5,000 postlarvae /m^2 in an indoor pond to prevent disease for around 20-30 days. Shrimp need intensive care while forming the hepatopancreas (shrimp's liver and intestine). The indoor shrimp pond also provides less environmental change for shrimp. After 20-30 days, shrimp become stronger and are tested before moving into bigger outdoor shrimp ponds. If shrimp are infected, farmers could discard them, which will not infect outdoor shrimp ponds. In outdoor ponds, shrimp density is around 533 shrimps/m^2. After one month, farmers could redistribute shrimp to the other two ponds to decrease the density to 266 shrimps/m^2 for lower risk. They would breed shrimp for around 70-90 days (Figure 38). Ming-Yi also adopted this model but has a different strategy. Ming-Yi explained that by breeding shrimp longer, shrimp are exposed to higher risks. According to his experience, Ming-Yi argued that shrimp are vulnerable in two periods: in the first 20 days and after 60 days. The difference is he shortened the growth time of whiteleg shrimp in outdoor ponds to 60 days and brought them to the processing factory in the 60th-70th day. This strategy helped Ming-Yi take over the market niche of small shrimp and speed up the flow of capital.

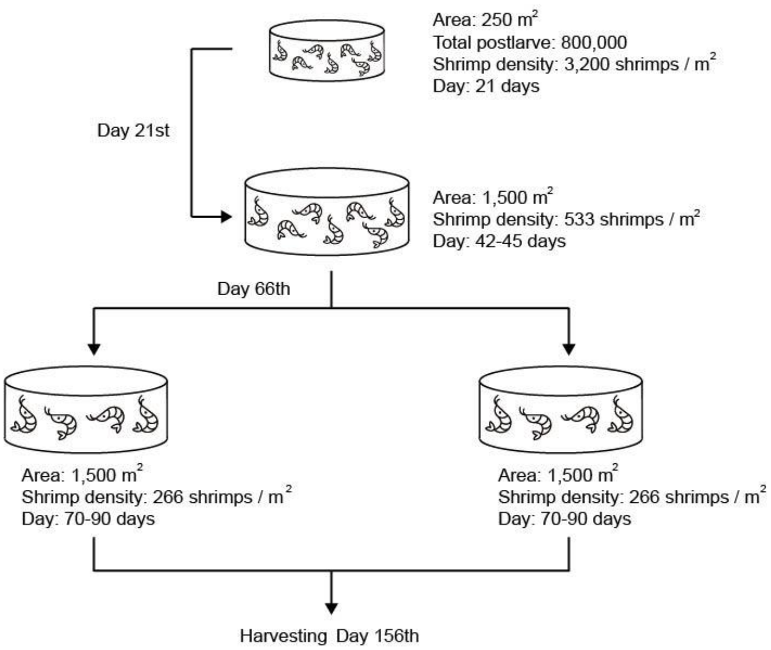


Figure 38 The schedule and density of super-intensive shrimp farming
Source: Unpublished manuscript from Hùng; image from (Chanut is Industries, 2021)

Although super-intensive shrimp farming detaches from soil and maintains water quality on the local scale, it is still embedded in the wider deltaic environment. Ming-Yi brought us to the other unused shrimp ponds and explained to the Taiwanese investors how to extract fresh water and salty water from the river. However, one of the potential Taiwanese investors was not convinced. He argued that the water and wastewater were all from the same canal, which could cause shrimp diseases. Water in canals and rivers is a common good. Farmers and companies did not pay any fee to the government. Farmers downstream would extract wastewater discharged from shrimp ponds upstream (cf. Barnes, 2014). Ming-Yi provided two solutions for water quality management. First, his workers only imported water during the high tide since seawater is clearer than river water. Second, they purified and sterilised water in their local water reservoirs before using it. Ideally, the water reservoir should be three times larger than shrimp ponds for changing the water every day.

The problem of wastewater pollution drew the government’s attention. Due to a requirement from the Ministry of Natural Resources and Environment, super-intensive shrimp farming now has to treat wastewater before discharge into rivers. From 2018 to 2020, the Department of Natural Resources and Environment in Cà Mau conducted a two-year project to compare different models of wastewater treatment. In my fieldwork, Hải, a Vietnamese farmer, had the facilities of wastewater treatment at the entrance of his shrimp ponds (Figure 39). The wastewater treatment facility was an underground biogas tank and decomposed the organic waste for a few hours. However, it was hard to monitor super-intensive shrimp as to farmers whether they used the treatment device.

Figure 39 Wastewater treatment in super-intensive shrimp farming
Source: Author

This section has compared hydro-social lives in four kinds of shrimp farming from two aspects: water-shrimp-humans-delta relations and agrarian, technical, and environmental changes. I showed how water-shrimp-humans-delta relations are both underpinned and impeded by the deltaic environment. The four kinds of shrimp farming were affected by the spatial and seasonal variation of water quantity and quality in the Mekong Delta. Improved extensive shrimp farming, intensive shrimp farming, and super-intensive shrimp farming mobilised devices and infrastructure to manage shrimp ponds and cope with the unstable water quantity and quality in the delta. On the other hand, breeding shrimp with different models required farmers, workers, and capitalists to adjust their everyday lives to fit with the life of shrimp. These four kinds of shrimp farming unevenly caused agrarian, technical, and environmental changes. Shrimp polyculture breeds shrimp with natural rhythms within the delta. Farmers learned to breed organic shrimp with mangroves or with rice in different seasons. Shrimp monoculture faced more uncertainties. Farmers doing intensive shrimp farming often mobilised family kinship and community ties to mitigate the economic loss of shrimp diseases. Capitalists conducting super-intensive shrimp farming deploy capital and technology to adjust their farming strategies to reduce the risk of shrimp disease.

5.3 Turning shrimp into a commodity

Things are rendered as “economic” rather than born as a commodity (Ouma, 2015: 143; Tsing, 2015). Shrimp become a commodity when they are detached from the commodity frontier (water and delta) and attached to global prices. Harvesting is a part of hydro-social life that depends on social, biophysical, and planetary rhythms and which effects the shift from organism to commodity. In monoculture, thousands of shrimp are captured from shrimp ponds; in polyculture, shrimp are discerned from leaves, fish, crab, and other species. Shrimp are graded by size and weight, and these numbers are associated with global price sheets. Global prices affect local transaction prices through the circulation of price sheets between farmers and traders on websites and messaging Apps. The organisational form and market structure influence the transaction process, the negotiation of price, and even the harvesting. Hydro-social lives in the Mekong Delta are not local phenomena but articulate with global factors. To capture the process of shrimp becoming a commodity, I observed the harvesting of black tiger shrimp in integrated mangrove-shrimp farming and that of whiteleg shrimp in super-intensive shrimp farming.

5.3.1 Harvesting and trading black tiger shrimp in the mangrove forest

The harvesting of black tiger shrimp in mangrove forests depends on biophysical and planetary rhythms. The harvesting period is from the 3rd to the 8th lunar month when shrimps are in the harvestable size. Farmers harvest shrimp during the low tide at midnight on the 15th or 30th day of the lunar month. During low tide, they open the sluice gate of their shrimp ponds. Water flows out when the water level in the canal is lower than their shrimp ponds. Farmers harvest shrimps at the gates between shrimp ponds and canals (Figure 40 and Figure 41). The 15th or 30th day of lunar months has the highest tidal range, so-called spring tides, enabling farmers to open the sluice gate for longer and collect more shrimps. Farmers harvest shrimp several times until the 8th lunar month when almost all the shrimp are captured.

As a researcher, I needed to synchronise my research schedule with the rhythm of nature. In August 2020, after finishing fieldwork, Sơn, a technocrat from the Department of Hydraulic Infrastructure, brought me to visit Nghĩa, his friend at university. Nghĩa was the vice-principal of a high school in Cà Mau peninsula but had a mangrove shrimp pond. Nghĩa was very hospitable and invited me to observe how they harvest shrimp next time. It was quite difficult for foreign researchers to visit the shrimp harvest in the mangrove forest. Due to governmental regulation, my schedule in the restricted area needed to fit with the application. I arranged my schedule to fit

Figure 40 A sluice gate between the shrimp pond and the river
Source: Author

Figure 41 A sluice gate from the view of the river during the low tide
Source: Author

with the lunar calendar and farmer's schedule. After that, I applied for the research permission three weeks before the date and waited for research permission from the local government. In the end, I was permitted to observe shrimp harvesting in mangrove forests in a restricted zone overnight.

It was the mid-autumn festival (the 15th of the 8th lunar month). My driver and I were in Cà Mau city centre and waiting for Sơn to drive down to the village. It was a

90-minute drive from the city centre to Nghĩa's house in the county town. It was 7pm, and the sky was already dark. The mangrove-shrimp pond was on the outskirts of the county town, so we rode motorbikes to Nghĩa relative's home. After a while, the road became narrower. One side of the road was a canal, and the other side was mangrove-shrimp ponds. On the way, we met a family harvesting shrimp in the middle of the street and blocking our way. Their sluice gate was just beneath the road, and they were harvesting shrimps. Nghĩa's shrimp pond and his relative's home were at the end of the road. We had dinner and beer first, and I was confused about whether I was doing my fieldwork or having a feast. After a while, Nghĩa suddenly jumped up and said it was time to harvest shrimp, and we walked to the sluice gate. I noticed that they put a moon cake and incense upon the sluice gate to pray for good luck (Figure 42). Nghĩa, wearing a flashlight on his head, was pulling a net up and pouring all its contents into a huge bucket (Figure 43). He carried the bucket back to the house and poured all the harvest out on the ground: there were mostly leaves and branches. Sơn, Nghĩa, and Nghĩa's relatives were finding the crab within the leaves and tied them up first (Figure 44 and Figure 45). We sorted out different kinds of shrimp, crab, and fish. They only collected big shrimp to make 20 shrimps/kg and put back smaller shrimp. It is polyculture shrimp farming so that there are many species in the shrimp pond. Only black tiger shrimp are put into ponds as postlarvae from hatcheries by farmers; other kinds of crab, shrimp, and fish, such as whiteleg shrimp and greasyback shrimp, were from the canal when farmers imported saline water into ponds. On that night, we only harvested shrimp twice. Nghĩa told me that it was the end of shrimp farming season so that there were not many shrimps. If there were still lots of shrimp in the pond, they would usually harvest shrimp for three days.

Figure 42 A moon cake and incense upon the sluice gate
Source: Author

Figure 43 Nghĩa is harvesting shrimp, crab, and fish upon the sluice gate
Source: Author

Figure 44 Shrimp and crab with leaves

Source: Author

Figure 45 Sorting out black tiger shrimp

Source: Author

After collecting the shrimp, they put the shrimp into ice water to keep them fresh and waited for traders to buy them the next day. Nghĩa wrote down the amount of each kind of shrimp and crab. In mangrove-shrimp farming, farmers did not have to contact traders because traders knew that farmers collect shrimp during spring tides. Due to the small road, the next morning buyers will come to farmers' houses by boats to purchase the shrimp and ship them by boat through the canal.

5.3.2 *Harvesting and trading whiteleg shrimps from super-intensive shrimp ponds*

In mid-August 2020, Ming-Yi told me that he was cooperating with the younger sister of the chairman of the National Assembly of Vietnam on a new food chain restaurant business and food safety project. For this new business cooperation, Ming-Yi planned to make a promotional video for his company. I was lucky to attend the filming in the shrimp farm with photographers and observed how Vietnamese workers harvest shrimp for the purpose of the video making. It was one of only a few chances for me to see shrimp on the farm. While visiting the shrimp ponds, I rarely saw shrimp because they are benthic animals beneath the water surface. Shooting the promotional film made workers and shrimp perform for the camera.[18]

Before harvesting, the buyer drove his truck to the shrimp ponds and carried the ice down to the ground. Vietnamese workers were already waiting around the shrimp pond (Figure 46). Two workers were removing the air pipelines from the shrimp ponds. After a while, four workers jumped into the pond holding two nets and walked clockwise. While workers walked pass part of the pond, some shrimp jumped over the water surface. I was walking along the pond behind the workers and avoided being shot by the photographer's drone. I noticed that shrimp not captured in the net were twitching up to the surface and swimming down (Figure 47). Obviously, shrimp were affected by (or scared of) workers and the sunlight. Normally, farmers observe shrimp on the farm at 6am. It was 10am. However, Vietnamese workers were very shocked to see the drone flying above them. Male workers in the shrimp pond splashed water up to the sky; female workers outside the shrimp pond used their mobile phones to take photos of the flying drone (Figure 48). A female worker told me that it was weird to see something

[18] Ming-Yi told the photographer that he must use his drone to shoot the Ba Lai river in Bến Tre since Bến Tre is the hometown of the chairman of the National Assembly of Vietnam. Ming-Yi thought that the chairman would be very proud of the shrimp from her hometown.

flying that low. Both humans and shrimp were affected by the encounter of human-shrimp-drone connection. After workers in the pond walked in a circle, all the workers gathered in one place. Workers outside the pond threw bamboo bags into the pond, and workers in the pond enclosed the nets and put the shrimp into the bags. Workers outside the pond used long bamboo sticks to carry the bags with shrimp to the truck. The bamboo bags were placed upon a rack to drain the water. After a while, the workers poured shrimp into plastic blankets and weighed the shrimp at 15 kilograms per blanket (Figure 49). A worker was standing beside the trader and making notes. After weighing the shrimp, another worker put the blankets into a bucket of ice water to wash the dirt away.

Figure 46 Vietnamese workers waiting around the shrimp pond
Source: Author

Figure 47 Workers harvesting shrimp and shrimp jumping over the water surface
Source: Author

Figure 48 The drone and Vietnamese female workers: one of the workers was so shocked that she squatted down.

Source: Author

Figure 49 Workers are draining water from bags, and buyers are weighing each bag and packing it into their truck
Source: Author

The size of shrimp determines the market niche of shrimp. In this harvesting, the size of shrimp is around 80-120 shrimps per kilogram, which is a smaller size among markets. Since Ming-Yi is both producer and processor in the value chain, he has more power to determine either selling shrimp to traders or processing them by himself by comparing prices. Ming-Yi made most of his profits from processing shrimp rather than breeding shrimp. He was focusing on the production of small-size shrimp since the market for small shrimp was previously occupied by Chinese farmers and companies. However, in recent years, China decreased the amount of production of small shrimp, so Ming-Yi wanted to take over this market niche. The market niche of Vietnamese whiteleg shrimp in the world was processed foods, not whole shrimp. His company is specialised in processing products for Chinese hotpot restaurants and other big shopping malls. The products of his company were shrimp balls, minced shrimp, and tempura, which are all processed products.

Although Ming-Yi had a plan for his business, it was difficult for Ming-Yi to recruit workers to peel shrimp shells, which was a less attractive and labour-intensive work. Ming-Yi solved the problem of labour shortage through the cooperation project with the chairman of the National Assembly. With that project, Ming-Yi was able to hire 800 male and female prisoners for peeling shrimps. Ming-Yi's business showed the combination of cheap nature, cheap food, and cheap labour in the shrimp processing industry.

5.3.3 The formation of prices and social organisations of transaction

The price of shrimp is highly embedded in the global market. Phương always told me that once shrimp are big enough to see, traders will come to buy them: no need to worry! She believed that the demand for shrimp is usually high, and sluggish sales rarely happen. In fact, the financial crisis in 2008-2009 impacted the global demand for shrimp and shrimp production in the Mekong Delta. Furthermore, the outbreak of COVID-19 significantly influenced the price of shrimp and the shrimp industry in Vietnam as demand for shrimp in China decreased significantly, driving down prices in Vietnam. In February 2020, for example, the price of whiteleg shrimp in Bạc Liêu was lower than the normal price due to COVID-19. Similarly, in March 2020, Ming-Yi also told me that his business was affected by the coronavirus because most of his processed shrimp products were exported to China.

Because shrimp is a global commodity, the local price of shrimp is often linked with the global price by referring to price sheets, which are circulated among governmental websites, Facebook, Zalo, LINE, and other messaging APPs. The price sheet shows that the transaction unit is based on the amount of shrimp per kilogram (Figure 50). The transaction unit ranges from 30-50 shrimps/kg to 130-150 shrimps/kg, which determines the unit price. The bigger shrimps are, the fewer shrimps per kilogram are, and the unit price is higher. The smaller shrimps are, the more shrimps per kilogram

Ngày cập nhật: 05/07/2020

	GIÁ TÔM THẺ THAM KHẢO TẠI SÓC TRĂNG		
DABM BINH MINH	ĐVT: Ngàn đồng		LÊN CON
Size	Từ	Đến	
15	196	203	5,000/con
20	171	178	5,000
25	141	148	6,800
30	128	135	2,600
35	124	132	800
40	117	125	1,400
45	114	122	600
50	104	112	1,000
55	102	110	400
60	98	106	800
70	94	102	400
80	93	101	600
90	89	97	400
100	85	93	400
110	82	90	300
120	80	88	200
130	78	86	200
140	76	84	200
150	72	80	400
Giảm 2.000 đồng từ size 15 đến 20 con			
TÔM GIỐNG GIA HÓA BÌNH MINH			

Figure 50 The reference price for whiteleg shrimps in Sóc Trăng (5th, July, 2020) [*The upper rows within the column: price unit 1,000 VND (ĐVT: Ngàn đồng) from (từ) to (đến); the lower rows within the column: reducing 2,000VND size from 15 to 20 shrimps*]
Source: (Tôm Giống Bình Minh, 2020)

are, and the unit price is lower. In Vietnam, Thailand, and Indonesia, shrimp price sheets work as a prosthetic price, which is "*a price form produced in the market, but not directly deployed by either buyer or seller in the actual exchange of commodities*" (Çalışkan, 2010: 23-24). Shrimp price sheets are a market index and a reference for farmers and dealers to understand the market information and make the actual price of shrimp. Unlike the mushroom-buying practice in Open ticket, Oregon or the pit trading of cotton in Izmir, Turkey, where prices are negotiated through the practice of auction, actual prices of shrimp are mainly offered by the cooperative, private merchants, and processing companies with the reference of price sheets (Çalışkan, 2010: 85-97; Tsing, 2015: 74-83). In intensive and super-intensive shrimp farming, if farmers want to sell their shrimp, they will call local buyers to inquire about the price. Local buyers would ask the processing companies to know the shrimp price of the day, deduct the harvesting and delivery cost from the price, and provide a lower price to farmers (Marks, 2010: 199). Private merchants and processing companies collect information about the demand and supply of shrimp in the global market from market reports written by agencies, such as Agromonitor and Thủy Sản Vietnam. They then negotiate shrimp prices with their foreign buyers.

In Vietnam, cooperatives (hợp tác xã) and clusters (tổ hợp tác) are viewed as socio-economic organisations that help small householders to have financial and technical support and more power for price bargaining. The government and international NGOs have been encouraging farmers to attend cooperatives and clusters, but the history of collectivisation made farmers, especially in the Mekong Delta, less willing to attending cooperatives. Ha et al. (2013) argue that clusters offer more technical cooperation and independent cooperation among farmers but do not provide a stable price to farmers. Thus, cooperatives and clusters in the Mekong Delta have limited abilities to empower farmers' bargaining power on transaction prices.

The transaction of whiteleg shrimp in villages is embedded in friendship and loan relationships between farmers and middle buyers. Farmers do not always sell their shrimps to buyers providing the highest price. Instead, farmers tend to sell their shrimp to acquainted buyers. One day, Thành drove me to visit Linh, a shrimp buyer, in the village. In Linh's office, there were two large-size self-portrait photos on the wall with proper make-up and dressing, which implied her high economic and social status in the village. Linh has been running her company for more than 20 years. Thành always sold his shrimp to her. She agreed that building trust with farmers is more important than providing the highest price to farmers. As Tsing (2015: 272) argued, trust (a kind of friendship) was not equal to consensus or equality but is related to reciprocal obligations depending on social roles. When farmers had financial difficulties, Linh lent them money or helped them breed shrimp, which formed the debt-creditor relationship in the village. It was fine that if indebted, farmers do not sell their shrimp to her, but they must pay her money back. She told me that there is no secret in the village; people knew that farmers sell their shrimp to whichever shrimp buyer. The social relationship in the village also prevented farmers from being cheated. I told her that I had seen the news that some farmers in the Mekong Delta were cheated by buyers offering higher prices or robbed by the mafia. Thành and Linh laughed and answered that it rarely happens in the village because people usually know each other and seldom trade with strangers. Furthermore, farmers should also be aware of those abnormal higher prices.

However, it does not mean that farmers are not profit seekers. Once Thành drove me to the mansion of Prince of Bạc Liêu for sightseeing, we met a seller of longan on a motorbike at the entrance. Thành asked the vendor about his purchase price of longan and gave him a phone number. Although the profit of longan is lower than that of shrimp, Thành still tried to get higher prices. Selling longan and shrimp have different methods. The transaction of longan was more straightforward than that of shrimp. I have helped Thành harvest longan once, and a buyer just came to Thành's farm and made a deal. However, harvesting shrimp required workers and a refrigerator van from buyers. Buyers have a key asset — the refrigerator van — that is required to maintain and realise the value in the shrimp via market exchange.

This section depicted shrimp harvesting in the integrated mangrove-shrimp farming and super-intensive shrimp farming, outlining the formation of shrimp prices and the social organisations that enable shrimp transactions. Harvesting marks the end of hydro-social life as shrimp then become commodities for exchange. In mangrove forests, farmers harvesting shrimp utilised the tidal range during the high tide and sorted shrimp out from leaves, branches, and other species. In super-intensive shrimp ponds, capitalists and investors harvested shrimp when they grew into marketable sizes. Workers used nets to collect shrimp, and traders weighed bags of shrimp. The shrimp price was mostly determined by traders with the reference of global shrimp prices (price sheets), and the buyer-seller relationship operated through trust and social ties among processors, traders, cooperatives, and clusters and in the village.

5.4 Conclusion

In this chapter, I have shown how farmers, workers, and investors grow shrimp on the commodity frontier of the Mekong Delta, focusing on three dimensions: contextualising shrimp farming in the Mekong Delta, comparing hydro-social lives in four kinds of shrimp farming, and observing shrimp commodification.

First, the development of shrimp economies in the Mekong Delta is multidirectional and heterogeneous. It was articulated with multiple spatialities and temporalities across different physical locations and social relations, resulting in four kinds of shrimp farming. Shrimp farming was adopted for economic development, poverty alleviation, and climate change adaptation. Integrated mangrove-shrimp farming was a compromise between mangrove afforestation and farmers' livelihood. Improved extensive shrimp farming was an adaptation strategy from governments and the research institute for farmers to tackle the seasonal change of freshwater and saline water. Due to climate change and saline water intrusion, intensive shrimp farming was deployed in a Khmer minority community as a development and poverty alleviation project. As for super-intensive shrimp farming, some farmers, urban elites, and foreign investors upgraded their shrimp ponds into this model to increase their economic incomes and reduce the risk of shrimp disease. Thus, the expansion of intensive and super-intensive shrimp farming for increasing productivity was only a part of the story on the commodity frontier. Shrimp economies on the commodity frontier developed in multiple directions and with diverse concerns.

Second, shrimp aquaculture reconfigures hydro-social lives in two aspects: water-shrimp-human-delta relations for ecological conditions of production and agrarian, technical, and environmental changes in the Mekong Delta. Water-shrimp-human-delta relations are shaped through the fashioning of shrimp domus, husbandry practices, and the management of shrimp disease. The polyculture type of shrimp farming utilised ecosystem services and the rhythm of the delta to grow shrimp; shrimp monoculture mobilised devices and infrastructure to overcome natural barriers and reduce the risk of shrimp disease to accelerate the life cycle of shrimp and speed up the return on capital. The polyculture model was highly influenced by natural environments, like feeding shrimp by the natural food chain and facing unstable water supply and quality in the delta. It did not engage in the shrimp feed business and had lower risks of shrimp diseases. In the monoculture model, farmers, particularly in intensive shrimp farming, were more vulnerable to shrimp diseases and mobilised resources from kinship and community to alleviate the economic loss. Urban elites and foreign capitalists utilised the plastic mat pond and two-stage production to reduce the risk and hire workers to care for shrimp. It showed that the shrimp industry operated along existing class lines but was still supported by more-than-capitalist relations (Belton et al., 2011).

Third, shrimps are rendered economic and turn into a commodity when they are detached from the commodity frontier and attached to global markets. The process of detaching still relied on water-shrimp-human-delta relations. In integrated mangrove-shrimp farming, the timing of shrimp harvesting depended on deltaic and planetary rhythms. In the other three kinds of shrimp farming, farmers harvested shrimp when they were in marketable sizes or infected by diseases. After harvesting, shrimp were sorted and weighed into different categories and associated with global shrimp prices. Local prices of shrimp are enrolled with global shrimp markets through price sheets and other price signals among processors, traders, cooperatives, and clusters. In the transaction, trust and social ties play a crucial role in the commodification of shrimp.

Chapter 6. The Hydro-Social Life of Experimental Shrimp: Water, Labs, and Biosecurity

In Chapter 4 and 5, I referred to how hydro-social lives in the hatchery and the Mekong Delta are constantly cared for and maintained through biosecurity concerns. This chapter analyses the research phase of shrimp economies by observing how the laboratory is a crucial site for providing biosecurity services and producing biotechnology commodities. It generalises three kinds of laboratory practices for biosecurity in shrimp economies: laboratories for testing, disease prevention, and experimentation (Table 8).

Section 6.1 analyses how shrimp and pond water from the field are tested in labs for biosecurity concerns. Testing water quality and the health status of shrimp is the first step to monitoring the risk of shrimp disease. Labs conduct water quality testing, PCR testing, and histological testing with water and (dead) shrimp from hatcheries and shrimp ponds to practise biosecurity. Testing makes elements and microbes in water visible and shrimp diseases legible. With the testing results, farmers and companies can adjust pond management and make economic decisions.

In section 6.2, this research focuses on how scientists developed two anticipatory logics of biosecurity in the lab and later applied them in the field: (1) securing shrimp health via pathogen management and immuno-preparedness and (2) using life to manage life. The first method focuses on shrimp itself by innovating SPF shrimp and vaccines to prevent hereditary infection and enhance the immune system of shrimp. The other logic emphasises ecological and environmental management by using life to manage life and water ecologies (cf. Lorimer, 2020). They develop probiotics for water, shrimp intestines, and shrimp feed. Although having done many trials and experiments in well-controlled laboratories, scientists and companies still need to confront many

Table 8 The role and function of the lab in shrimp economies

Role	**Laboratory for testing**	**Laboratory for disease prevention**	**Laboratory for experimentation**
Spatiality	Shrimp and pond water move from the field to the lab	Biotechnological commodities and solutions travel from the lab to the field	Shrimp within the lab and knowledge travel from lab to the field
Biosecurity	Testing: ● Knowing water quality and ecology ● Monitoring shrimp health	Innovating: ● Pathogen management (SPF shrimp) ● Immuno-preparedness (vaccines and the viral accommodation model) ● Using life to manage life and environment (probiotics)	Experimenting: ● Feeding and caring for shrimp (shrimp feed trials) ● Poisoning and killing shrimp with bacteria and viruses (disease challenges)
Hydro-social life	Making water-pathogen-shrimp-human-environment relations visible	● Modifying shrimp itself ● Managing water-pathogen-shrimp-human-environment relations	● Reconfiguring water-pathogen-shrimp-human-environment relations into observable and controllable conditions

Types of the lab	• Improvised labs in the retail shop • Governmental diagnostic testing stations • Private aquaculture labs	• Governmental diagnostic testing stations • University labs • Private aquaculture labs	• Private aquaculture labs

Source: Author

uncertainties in the field (Henke, 2008) to make their solutions practical and their innovations commercially viable for biosecurity.

Section 6.3 unpacks how hydro-social life is cared for in the context of shrimp experimentation in a lab. Shrimp experiments show a different logic of biosecurity, where scientists use bacteria and viruses to poison and kill shrimp to develop biotechnological commodities. It creates a distinctive form of hydro-social life: water is prepared and monitored, and shrimp as the laboratory animal is fed, controlled, observed, poisoned, and killed. This instrumental relation between science and the experimental animal is framed within shrimp economies for customers, which renders their life form itself a potential commodity in the capitalist form of life that organise laboratory tasks. Although shrimp are analytical tools, technicians are still affected by them and face ethical issues of experimenting on shrimp.

6.1 Laboratory as a clinic: Testing shrimp health and water quality

In the Mekong Delta, shrimp are exposed to the risk of new diseases, such as Taura Syndrome, White Spot Syndrome (WSS), Shrimp Early Mortality Syndrome (EMS), and other emerging diseases caused by viruses and bacteria. For biosecurity concerns, farmers and companies can bring their shrimp and pond water to improvised labs, governmental stations, and private labs for testing services. Thus, the laboratory is a clinic for knowing water quality, water ecologies, and the health status of shrimp.

6.1.1 Testing shrimp and water quality

In the Mekong Delta, I saw many improvised labs providing water quality testing services because testing was a well-established and mundane practice. One day, I visited several shopkeepers selling shrimp feed and medicine in Bạc Liêu. In these shops, shopkeepers installed an improvised door and windows to create a simple lab room, distinguished from the retail space (Figure 51). In this lab room, there were reagents for water testing, a microscope on the desk for identifying algae, and a poster on the wall showing disease symptoms. The shopkeepers told me that farmers bring their pond water and receive testing for free, even if farmers do not buy any products. The free testing included water quality and algae testing. Interestingly, these labs with free testing services were embedded within commercial space. Shopkeepers said testing is an essential and necessary service for attracting potential customers and maintaining customer relationships (or even friendships).

Figure 51 An improvised lab in a shrimp medicine shop.
The banner with cartoon, humanised and healthy shrimp says: "*Quality makes confidence (Chất lượng tạo niềm tin).*" The red words on the glasses are "*testing environmental water quality for free (Kiểm tra chất lượng môi trường nước miễn phí)*."
Source: Author

Shopkeepers usually hire one or two clerks to serve customers and conduct the testing service. The clerks did not have any background related to aquaculture. They learned testing methods from previous clerks since these methods were simplified and standardised. The clerks shared water quality testing reports with me. The reports were the testing result of pond water quality from farmers. They indicated the levels of water salinity, pH value, ammonia, nitrogen dioxide, and other chemical elements. They also analysed good and bad algae, such as *Pyrrophyta*, *Euglenophyta*, *Cyanophyte*, *Chlorophyceae*, and *Thalassiosira*, in pond water. With these reports, clerks compared water quality with a normal standard to give suggestions to farmers on how to adjust their pond management. However, with limited ability and equipment, clerks could only diagnose diseases from their experience or by comparing shrimp with the symptom poster on the wall. If farmers wanted a more accurate diagnosis, they needed to get polymerase chain reaction (PCR) testing in other labs.

Governmental diagnostic testing stations for aquatic animals (Trạm Kiểm dịch Thủy sản) and private aquaculture labs have more equipment and advanced techniques. They provide farmers and companies with histological, microbiological, and molecular biological testing, including PCR testing, for postlarvae and shrimp. Once I visited a governmental aquaculture research institute in Cà Mau. The reception room had posters with photos of infected organs and tissue slices under the microscope and service prices. On a price sheet, they had two or three kinds of testing for the same diseases, and customers could decide which disease they wanted to test for and how quickly they wanted to know the results. The more accurate the results, the higher the prices, and the longer it takes.

Dr Anh's private lab provided similar disease diagnostic testing of postlarvae and shrimp for both companies and farmers. Farmers have to send their shrimp and pond water from the Mekong Delta to Dr Anh's lab in Hồ Chí Minh City. When farmers called to the office, a receptionist would ask them some questions. What is the colour of the shrimp? Do any organs of the shrimp look abnormal? What is the colour of the water in the shrimp ponds? Do shrimp eat more or less than usual? After answering these preliminary questions, farmers received instructions for sampling and packing. Once I saw a courier deliver a styrofoam box, containing a plastic bag of dead shrimps and two bottles of pond water from a farmer to the lab. The farmer asked for PCR testing and microbiological testing. I shadowed technicians to see how they conducted tests. Technicians dissected the dead shrimps and collected hepatopancreas in the molecular biology lab for PCR testing. In the microbiology lab, other technicians diluted the pond water and reared *Vibrio vulnificus*, which is a kind of bacteria and one of the main pathogens for shrimp, on a Petri dish with agar. After 24 hours, they counted the number of clusters of bacteria within the Petri dish. Through these tests, viruses, bacteria, and algae in shrimp and the water became visible.

6.1.2 The purposes and effects of testing

Testing is a method to manage water-pathogen-shrimp-human-environment relations. Testing water quality and shrimp health is an essential and continuous practice for two purposes: checking water ecologies and monitoring shrimp health.

PCR testing is applied for breeding shrimp from production to reproduction, such as breeding broodstocks, buying postlarvae, and growing shrimp, to know the health status of shrimp. In labs, scientists used PCR machines to test whether broodstocks, larvae, and shrimp are infected. In the field, some farmers had a portable PCR machine and knew how to do simple testing. They did not have to know the principle or knowledge of diagnosis but how to use the equipment and testing results to manage their shrimp and ponds.

On the other hand, breeding shrimp also requires carefully managing water quality. Shrimp live in water, and water quality determines their health. Unlike marine aquaculture in open water, shrimp farming in brackishwater aquaculture is on the land within a containment; a large size aquarium. It has a different water management strategy. One day, I was in Dr Anh's private lab and saw an academic book, *Water Quality in Ponds for Aquaculture,* written by an American scholar Claude E. Boyd, on a table. The senior technician told me that this book was given by her undergraduate supervisor and is still a key reference for Vietnamese aquaculture students. Water and pond management is still crucial knowledge in aquaculture.

Knowing test results helps farmers and companies to adjust pond management and make economic decisions. When farmers find their shrimp have symptoms, especially close to harvesting timing, they usually want to know the results as soon as possible. If farmers find their shrimp is ill, they can sell earlier or breed shrimp carefully and sell them later. Some farmers are experts and willing to learn scientific knowledge even though they do not conduct testing and know the methods. In Dr Anh's lab, receptionists and technicians told me that some farmers are experts. After gaining experience with the tests, farmers did not need any consultants and just told them which disease they wanted to check.

However, not all farmers in the Mekong Delta adopt testing services. In integrated mangrove-shrimp farming, farmers usually do not undertake any testing because they breed "naturally," such as not using any shrimp feed and having a lower population density of shrimp. These farmers keep shrimp as in the wild so that the risk of infection is very low. Nor do some farmers in intensive shrimp farming do any testing. For example, Thành, who did intensive-shrimp farming, never sent his shrimp for PCR testing. When seeing his shrimp are ill, he usually sells shrimp to merchants immediately.

Water quality testing and PCR testing are not the best solutions and cannot eradicate diseases. Farmers and companies can only know water quality and shrimp health and then adjust their management. Once, I interviewed a Taiwanese shrimp feed researcher; he told me that "*when farmers noticed that their shrimps are ill, they usually* *find vets to help them and what farmers receive is a* ***death certificate*** *(testing reports).*" He thought knowing the health status of shrimp is usually too late to take action and what farmers and companies need is prevention.

This section analysed how water quality testing, PCR testing, and microbiological testing are practised in improvised labs, governmental stations, and private labs within and beyond the Mekong Delta. Farmers and companies do testing to know water quality, monitor shrimp health, and ensure postlarvae from hatcheries are pathogen-free. With the testing result, farmers and companies can adjust pond management and make economic decisions.

6.2 Disease prevention: Two anticipatory logics of biosecurity

The shrimp laboratory also developed more active and preventive biosecurity strategies by innovating biotechnological commodities. Scientists proposed two anticipatory logics of biosecurity: (1) securing shrimp health via pathogen management and immuno-preparedness and (2) using life to manage life. The first method focuses on shrimp itself with pathogen management by developing SPF shrimp and immuno-preparedness by innovating vaccines and interbreeding shrimp accommodating virus without the syndrome. The other method emphasises improving shrimp health by managing bacteria in shrimp bodies and water ecologies. They reshape different elements in water-pathogen-shrimp-human-environment relations. However, when these biotechnologies extend from labs to fields, they face many uncertainties, such as non-biosecure farming skills, the unstable performance of vaccines, and the misuse of probiotics. These products also need to fit with the business model of shrimp economies.

6.2.1 Pathogen management and immuno-preparedness: SPF shrimp, vaccines, and the viral accommodation model

Once I had a conversation with the vice-director of Dr Anh's lab. He told me that I should visit two renowned professors, Mei-Yu and Si-Ting, in shrimp biology in Taiwan. Dr Anh and the professors are friends, which shows the academic connection between Vietnam and Taiwan. In December 2019, I visited Mei-Yu, the famous university chair professor, and her research team, breeding the SPF black tiger shrimp in her laboratory in Taiwan. The breeding project of black tiger shrimp was funded by the Ministry of Science and Technology and cooperated with private companies. This project aimed to develop disease-resistant and fast growth larvae of black tiger shrimp and reinvigorate Taiwan's historic role as the empire of black tiger shrimp. In the interview, she said that although farmers mainly breed whiteleg shrimp, it does not mean that farmers do not want to grow black tiger shrimp. Prof. Mei-Yu argued that even though whiteleg shrimp have a faster growth rate and larger market share, the meat quality of black tiger shrimp is better. If farmers have SPF black tiger shrimp in the market, they will have a safer and better choice and lower risks of diseases. This conversation showed her hope, passion, and ambition for developing SPF shrimp to reshape the shrimp market.

The market of shrimp broodstock was new and not yet monopolised by a company. Vietnamese companies also developed their own shrimp broodstock. For instance, Thủy Sản Việt-Úc (Vietnam-Australia Joint Stock Company) identified three disadvantages of importing broodstocks from foreign markets: the limited supply of broodstock, especially at peak times, higher price, and the unstable quality (Tập Đoàn Việt-Úc, 2020). Thus, Việt-Úc established their line of SPF broodstock (10 generations of whiteleg shrimp family) to substitute the broodstock importation, which was a national building project. It tried to secure the supplement, keep the profits within the domestic industry and shape the broodstock market. On the Facebook page of Việt-Úc, they announced their success in building the line of broodstock with an interesting photo (Figure 52). In the photo, the technician did not wear a white coat but a shirt, tie, and plastic gloves. He was injecting an electronic chip to trace the health performance of shrimp. In the background, there was an aquarium with whiteleg shrimps and saline water, but shrimp are usually invisible in the field. It was a performance to display their scientific and industrial achievement in developing Vietnamese broodstocks.

Figure 52 A Việt-Úc technician injects an electronic chip into a shrimp in a presentation

Source: (Tập Đoàn Việt-Úc, 2020)

SPF shrimp are produced by inbreeding and genetic selection, reflecting how humans shape the evolution of shrimp. Scientists and companies produce SPF shrimp by collecting uninfected broodstocks from the sea. Prof. Mei-Yu and her research team worked with a French corporation and collected their broodstock from Madagascar, where shrimp are still uninfected. In the other case, Wen-Hua, a Taiwanese scientist from Agricultural Technology Research Institute in Taiwan, bought broodstocks of blue shrimp (*Litopenaeus Stylirostris*) from fishers and traders in Taiwan, Japan, and the Caribbean. These biologists needed traders to help them collect samples that enriched their genetic database. Scientists and companies breed broodstocks and larvae in a hatchery-like lab (see Chapter 4). They extract and mobilise biological resources from the sea through biotechnology for animal husbandry to build up a new business or even obtain patents through their shrimp family (Helmreich, 2009; Holloway et al., 2009). While breeding SPF shrimp, scientists need to identify genetic markers, select the preferred genetic traits, and do not interbreed with other shrimp not having preferred genetic traits to ensure genetic uniformity. However, SPF shrimp face many challenges when they become a commodity and move from the biosecure and lab-like hatchery to the less biosecure shrimp pond.

The selling of SPF shrimp faced some setbacks owing to different understandings of SPF larvae between sellers and buyers. SPF larvae are a health and sanitary status, but they can still be infected. The SPF larvae can only ensure that shrimp are not infected by specific pathogens, but they might contain other unknown viruses (Rosenberry, 2015). Moreover, using SPF larvae can only prevent hereditary infection but not infectious transmission after being sold to farmers. Prof. Mei-Yu also said that the disease-resistant larvae are not a panacea; farmers still need to maintain their shrimp ponds properly. It is not biosecure that farmers buy SPF larvae from the hatchery but still adopt vernacular farming, such as shared labour, water management, and stocking (cf. Hinchliffe et al., 2020). Even though it is not the panacea, many Vietnamese farmers still buy SPF larvae from hatcheries because no one wants to get ill postlarvae from the beginning.

SPF shrimp, as a fragile commodity, require the notion of trust to facilitate the transaction. When an Indian company wanted to buy SPF larvae of black tiger shrimp from Prof Mei-Yu, she did not sell SPF black tiger shrimp to them. She thought the Indian company did not have a proper biosecurity regulation in their shrimp ponds. If SPF larvae die as a result, it will tarnish her reputation. It shows that the buyer-seller relationship is not only about an immediate return but also the long-term commodity reputation owing to the precarious status of SPF larvae. In another case, while hatcheries sell the SPF larvae to farmers and companies, hatcheries usually prove larvae are specific-pathogen-free with the result of PCR testing from the lab. However, reports are just paper and do not always represent the actual status, becoming a trigger for business conflicts. While doing my fieldwork in Taiwan and Vietnam, I heard Minh-Yi complain about a Taiwanese company in Vietnam selling non-SPF larvae to him on several occasions, which caused him a severe economic loss. No one knew where the fault might lie since there were too many uncertainties in breeding animals. Minh-Yi thought that Taiwanese overseas investors should have supported each other in a foreign country. It implied that shared national identity or ethnic ties could be a basis of trust. In fact, the trust in Taiwanese enterprises' production network in Vietnam is not fully based on either national identity or ethnic ties but on practices of reciprocity (Chen et al., 2004). Trust is a precondition for the transaction, but the risk prevention of shrimp diseases is mostly related to farming skills and pond management.

Due to the limit of SPF shrimp in the shrimp pond, scientists developed a vaccine and the viral accommodation model to enhance the immune system and disease tolerance of shrimp. Scientists have recently been working on a gene involved in immune defence and immune receptor, known as the *Down syndrome cell adhesion molecule 1* (DSCAM-1) gene in Pancrustacean immunity (Armitage et al., 2017). With scientific development, humans can produce and inject vaccines for shrimp to form antibodies, but it is not commercially viable. Prof. Si-Ting cooperated with a company on shrimp vaccine. She told me that in her experiment, shrimp had antibodies after the first jab, but their performances were not consistent due to the immune memory of shrimp. Unlike poultry, livestock, and fish, shrimp are invertebrates and have a different immune system from vertebrates. Even when shrimp had the antibodies in the second month, shrimp grew into the marketable size and the company usually harvested shrimp in the next month. The time length of immune protection is too short and is not significant enough for business investment. Thus, the temporality of vaccine injection did not fit with the temporality of shrimp farming. The vaccine is not an ideal solution for preventing diseases due to the unstable performance and the commercial infeasibility of inoculation.

Contrasted to SPF shrimp models, other scientists developed the viral accommodation model for shrimp interbreeding. The viral accommodation model, first proposed by Dr Timothy Flegel, suggests that shrimp can be virus tolerant without the sign of disease. The mechanism in this model is that when shrimp are directly exposed to environments with pathogens, viral genome fragments become a part of the shrimp genome (Flegel, 2019). Therefore, scientists collect survivors as broodstocks from infected shrimp ponds (Rocha et al., 2015). This model was experimented with and went well in Thailand and Ecuador. However, it might be incompatible with super-intensive shrimp farming because of the high environmental pressure in shrimp ponds. It still requires further studies in the field.

6.2.2 Making shrimp and water probiotics

Instead of coming from outside, viruses and bacteria are already embedded within industrial farming systems, such as in the growth regime, stock density, and the timetable for clearing (Hinchliffe et al., 2016: 100). Emphasising SPF shrimp too much can obscure a greater understanding of how the industrial farming system itself shapes the formation of disease. Disease situations are meeting places where heterogeneous actors, species, and things mingle together (Hinchliffe et al., 2016: xv). It is crucial to prevent anaerobic bacteria and maintain shrimp ponds. When breeding more shrimps, farmers and companies cast more shrimp feed into ponds. As a result, shrimp ponds have more residue from feed, shell, and excrement. The waste settles on the bottom of the shrimp pond and becomes sludge, which forms more anaerobic bacteria. In another case, scientists also noticed that white feces syndrome in shrimp is associated with dysbiosis in the shrimp intestinal microbiota rather than a single pathogen (Huang et al., 2020). When shrimp intestines lack certain kinds of good germs, they become ill more easily. The outbreak of certain diseases in this context is a dysbiosis caused by the ecological irrationalities of capitalism and other political-economic drivers (see Lorimer, 2020: 135).

Aquaculture has turned its focus from managing life directly to using life to manage life by using probiotics to manage environments. Chung-I, a Taiwanese professor, claimed that it is impossible to eradicate either viruses or bacteria from shrimp and shrimp ponds. Even when shrimp are infected by some viruses and bacteria, such as *Vibrio harveyi*, they do not necessarily have any symptoms or become ill. Only when shrimp experience higher environmental pressure, like temperature change or too much anaerobic bacteria in water, does the virus and bacteria move from a lysogenic cycle to a lytic cycle, and shrimp get sick.[19] Thus, it is more efficient to prevent the disease by decreasing shrimp density, cleaning up the sludge in the shrimp pond, and increasing the proportion of good bacteria in the water. When there is a disease outbreak in the shrimp pond, farmers usually remove the sediment, which might contain the virus and the anaerobic bacteria, in the bottom after draining the pond. Farmers and companies need to use probiotics and discharge the sludge regularly. Prof. Chung-I

[19] Lysogenic cycle refers that the viral genetic material integrates with the host bacterial genome and replicates itself without any fatal consequences to the host; while lytic cycle is that the viral genetic material rapidly multiplies and disintegrate the host cell for releasing more viruses (Sharma et al., 2017). Generally, these two cycles are performed by two kinds of phages: virulent phages and temperate phages. Phages are viruses that infect and replicate within bacteria. Virulent phages only use the lytic cycle; while temperate phages mobilise both the lysogenic cycle and the lytic cycle. The lysogenic cycle shifts to the lytic cycle when a trigger, like chemical stimulus or environmental changes, stimulates the replication process.

proposed that we need to learn how to manage the environment and decrease the pressure in the shrimp pond by incubating probiotic bacteria and their preferred environment to depress the number of anaerobic bacteria.

Shrimp farming in Vietnam has also been undergoing a probiotic turn. Due to the concern of antibiotic-resistant bacteria in the Global North, the Vietnamese government promoted probiotics and forbade the use of antibiotics to obtain seafood certification and meet the importation requirement in the Global North (cf. Hinchliffe et al., 2020; Lorimer, 2020). Ming-Yi and Dr Anh were working on probiotics in shrimp production. Ming-Yi needed to comply with restrictions on medications and antibiotics in order to export his products to the US and EU markets in the future. It shows that the probiotic turn of consumption in the Global North shaped that of production in the Global South. This research recognises that the probiotic turn has uneven geography between Global South and North. Global North already has health and environmental policies for using probiotics to control microbial ecologies. However, the Global South mostly does not yet have enough economic, political, and ecological conditions to use probiotics (Lorimer, 2020: 9). Similar to shrimp farming in Bangladesh, many farmers in Vietnam still apply antibiotics to shrimp. Only a few farmers and companies use probiotics for a higher sale price. Hinchliffe et al. (2018) argue that the use of antibiotics is related to social relations and ecological conditions that shape food production. In Vietnam, farmers can buy antibiotics without prescription, which is one of the main factors for overusing antibiotics (Luu et al., 2021).

Shifting from using antibiotics to probiotics, or transitioning from a Pasteurian to a post-Pasteurian approach, in making good germs indicates new ecologies of shrimp aquaculture (Paxson, 2012; Paxson and Helmreich, 2014). In a post-Pasteurian approach, humans identify good and bad microbes and harness the former to vanquish the latter (Paxson, 2014: 118). In aquaculture, people use two kinds of probiotics to build new shrimp-microbial relationships: one for pond water and the other for shrimp intestines and shrimp feed. Biotechnology companies utilised these two kinds of probiotics to create their products to improve shrimp health and water ecologies.

In water management, Dr Anh proposed using good germs to depress the population of *Vibrio*. Dr Anh and his research team produced their probiotic products in his lab in Hồ Chí Minh City and the hatchery in Ninh Thuận. Dr Anh and his team bought some probiotic products, such as BiOWiSH MultiBio 3PS, BiOWiSH AquaFarm, AquaStar Pond, AquaStar Growout from BiOWiSH Technologies, an American biotechnology company, and AquaStar from an Austrian animal health and nutrition company.[20] The package of AquaStar states that "*the multi-species approach builds on synergies and complementary modes of action between different bacterial species, and ensures users are provided with maximum benefits*." It claims that the product could ameliorate water quality, organic matter in pond environments, pond sediments, and shrimp guts. Dr Anh also innovated aerobic bacteria products. In his lab, the aerobic bacteria are produced in a hot and humid room without air conditioning. In the room, technicians and I usually got very sweaty, but it helped bacteria reproduce rapidly. They made it in a huge plastic bottle and provided oxygen by an air pump (Figure 53). The technician used fermented soy milk and molasses as feed to proliferate bacteria for 24 hours. They also cultured photosynthetic bacteria in plastic bottles or sample bottles by lighting them in the microbiology lab.

[20] These two biotechnology companies also innovated products for poultry, swine and other crops for their drinking and irrigation water.

Figure 53 Probiotics for shrimp in the hatchery
Source: Author

Since the 2000s, Taiwanese shrimp feed companies have proposed an intestine theory and been applying probiotics and fermentation technology to their shrimp feed (cf. Lorimer, 2020: 54). A manager in a Taiwanese shrimp feed company told me that we needed to contextualise the use of probiotics. It was first applied to humans, livestock, then to shrimp. While designing shrimp feed, researchers have to consider molecular size in fermentation. When the size is smaller, shrimp's intestine can digest and absorb it more easily. They have fermented shrimp feed with green beans, banana skin, dragon fruit skin, or fish powder. During fermentation, microbes inhibit and compete with others and produce various kinds of secondary metabolites. The more diverse microbes one has, the more complex relations among microbes become, which is good for shrimp.

Although probiotics have gained more attention in shrimp aquaculture in the Global South, some scientists suspect the use of probiotics and their ecological reach. A Taiwanese scientist argued that "*the probiotic is just good for the digestion of shrimp-*

like some people drink Yakult, but it's not necessarily good for our health." Other scientists have researched probiotics and believe they might work, but their concerns are that the components of probiotics in the market are not standardised and not certified (Chen et al., 2017). It is hard to ensure the quality and content of probiotics in the market. Furthermore, when buying probiotics, farmers need to proliferate probiotics by themselves. They might incubate bad germs due to wrong reproduction techniques, such as not providing enough light and oxygen for microbes. Bad germs can pollute pond water and affect shrimp health.

This section analysed the process of commodity innovation in the lab and identified two anticipatory logics of biosecurity underpinning these biotechnological commodities. Scientists developed SPF shrimp, vaccines, and the viral accommodation model for pathogen management and immuno-preparedness. However, SPF shrimp can only prevent hereditary infection and still require careful pond management. Furthermore, complications arise when SPF shrimp become a commodity that needs trust between scientists and farmers to protect the reputation of their products. On the other hand, I have shown how some scientists have shifted their interest to the use of probiotics for shrimp, shrimp feed, and water ecologies. However, the efficiency of probiotics is still debatable because of unstandardised products and the possibility that farmers use incorrect methods for culturing germs in the field.

6.3 Laboratory animal and experiments: Breeding, poisoning, and killing shrimp

Some laboratories create a distinctive hydro-social life for conducting shrimp experiments. They conduct experiments to produce scientific knowledge and evaluate new shrimp feed from companies by breeding, poisoning, and killing shrimp. Like farmers care for their animals and fields, technicians and workers care for water, experimental shrimp, devices, and infrastructures in the laboratory (cf. Singleton and

Law, 2013). Technicians not only feed and care for shrimp but also poison and kill them through disease challenges and blood testing. These caring practices render affective and ethical states, such as attuning the bodies of technicians to shrimp to reduce pain and improve animal welfare.

6.3.1 Setting up the living environment in the urban wet lab

In the Vietnamese shrimp industry, only a few labs have a wet lab to breed shrimp and conduct *in vivo* experiments. Shrimp feed and processing companies tend to cooperate with academic or private labs to evaluate new products. Dr Anh's lab is different from governmental stations and university laboratories. It is a famous private shrimp lab in Vietnam, so it has a tight relationship with corporations to conduct more experiments and to be self-sustaining. Dr Anh worked with the biggest Vietnamese shrimp processing company and Hau-Ting's shrimp feed company. Dr Anh's lab provided testing services, the experiments of disease challenges, and the trials of probiotics and new shrimp feed for companies.

Before conducting *in vivo* experiments, Dr Anh and his team created the living environment for shrimp and the observable condition for the experiment. Shrimp were detached from their natural environments, and the laboratory was made into their new habitat.[21] Shrimp in this urban laboratory were kept alive with plastic bottles, coral stone filters, and air pumps. The research team assembled all these devices, equipment, and infrastructure to create a livable, controlled, and experimental space for shrimp, which could be deemed to be an aquarium (Figure 54).

[21] Labs are not completely same as their natural habitat since technicians just put shrimp into tanks and did not provide any environment enrichment, such as substrate, seaweed or other materials (see Message and Greenhough, 2019).

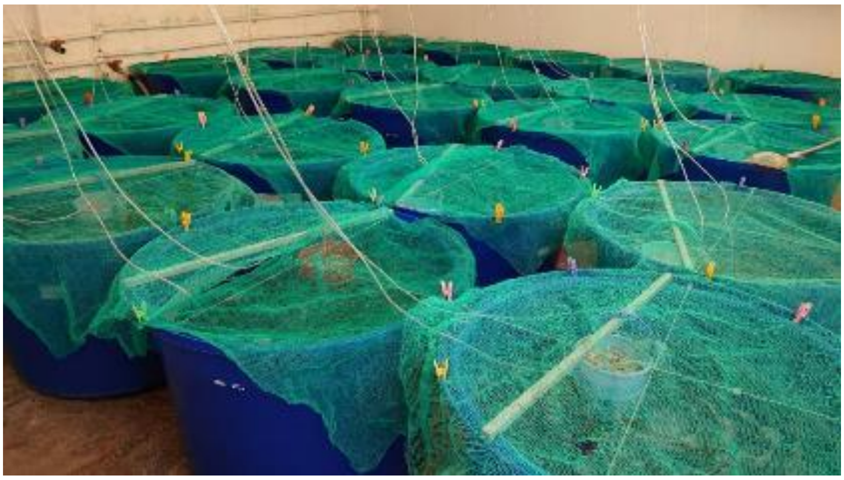


Figure 54 Shrimp in tanks with reefs filtering water
Source: Author

First, shrimp were kept in observable containers rather than ponds. The lab had two sizes of containers for various kinds of experiments with different amounts of shrimp. Medium-sized plastic bottles only contained a single shrimp for diseases challenges to compare the performance of individual shrimp. The larger size of plastic tanks contained a group of shrimp (around 20) for shrimp feed experiments to record their health status and growth rate.

Second, the research team mixed freshwater and saline water to maintain water quality in the containers. Dr Anh's lab is in Hồ Chí Minh City and far from the sea, but shrimp live in saline water. The research team bought four cubic meters of seawater every one or two weeks from seawater companies in Vũng Tàu, a coastal city. After the marine water was delivered by trucks, it was sterilised and prepared in two huge water plastic tanks.[22] After water treatment for two or three days, workers transferred and stored it in two towers beside the wet lab through a portable pump and improvised

[22] Sea water companies, in Vũng Tàu, mainly sell their sea water to seafood restaurants. Middle and high-class restaurants, in Hồ Chí Minh City (a river city), usually have aquariums to keep live fish, crab, lobster, and clam. Although Hồ Chí Minh City is closer to Cần Giờ, a town at the estuary, sea water there contains more sediments and lower salinity. The coastal city Vũng Tàu, which is not too far from Hồ Chí Minh City, has sea water with higher salinity and fewer sediments.

pipelines. The water in the wet lab was controlled by two taps: the upper one was saline water, and the lower one was freshwater. The technicians had already marked the water level of freshwater and saline water on the plastic boxes, so they just poured freshwater and saline water at the right level. Like caring for aquarium water, workers usually siphon cloudy water (with dissolved organic compounds) from tanks and refresh the water to ensure water quality. Third, oxygen provision is also important for the enclosed water. Due to the limited lab space, technicians bred shrimp in tanks and provided extra oxygen by air pumps with pipelines rather than installing ventilators on each tank. While having experiments, the air pumps constantly worked 24 hours every day.

This controlled and experimental space is a fragile network and needs to be cared for and maintained. The water treatment ponds, water towers, and wet lab were at times scattered in Dr Anh's lab. While I was watching technicians and workers preparing water, for instance, they ran out of saline water in their water towers beside the wet lab and had to transfer the saline water from the water treatment ponds by a pump. However, the pipeline was not welded properly to the pump, and saline water started spurting out. Another time, while they were moving the oxygen pipelines, the oxygen pipeline fell off and made a huge noise. It was common for warehouses and hatcheries to have alarms for the leakage and deficits of oxygen. When tanks did not have enough oxygen or one of the plastic pipelines falls off, the alarm can sense the pressure change and inform the workers to fix it as soon as possible.

After setting up this experimental environment, technicians and workers put shrimp into those containers. When I first saw shrimp in plastic containers and the arrangement of the wet lab, it looked like the movie *Matrix*, where humans live in womb-like pods, and their bodies connected with cords. Similarly, shrimp, in this urban lab, became cyborgs entangled with containers-water-pipelines-other infrastructures.

Cyborgs are not just machine-organism hybrids but dense material-semiotic things, ontologically heterogeneous and historically situated (Haraway, 2017: 104, 2018: 51). In this laboratory control space, humans were becoming-with shrimp, and the knot of shrimp-container-water-pipeline was composed for capitalist technoscience.

6.3.2 Caring, feeding, poisoning, and killing

Hydro-social life in this lab needs technicians and workers to be caregivers for scientific research. Dr Anh employed technicians to care for lab animals and maintain the apparatus. Technicians were trained in aquaculture. They planned lab schedules and conducted experiments.[23] Like super-intensive shrimp farming, workers, mostly men, in Dr Anh's lab did manual work and were requested to live in the accommodation so they could handle any situation immediately. Through this labour division, workers helped technicians do several jobs, such as preparing and taking care of SPF shrimp, refreshing clear water, washing containers, and conducting shrimp feed experiments.

At the individual level, technicians and workers prepared SPF shrimp for two reasons. By using SPF shrimp can ensure the accuracy of experiments because SPF shrimp are uninfected, and technicians can control the parameter of experiments. The other reason is that it helps to avoid the outbreak of shrimp diseases in the lab. At the population level, workers weighed shrimp, picked out the same size of shrimp, and put them into a plastic container to standardise each container for further experiments. After putting them into containers, workers added some vitamins and minerals to the water, keeping them healthy. After these preparations, Dr Anh's lab was very busy with different experiments in several warehouses, such as shrimp feed trials, disease

[23] Labs are also for teaching and scientist training (Myers, 2015). Some of them were Dr Anh's undergraduate students and worked with Dr Anh after the graduation. Others were graduated from another university famous in aquaculture. This shows that the positions of Dr Anh in both academic and private companies bring him to an unique niche in this market.

challenges, and blood testing.

Labs usually have many places in their buildings for various tasks (Law, 1994: 40). Dr Anh's lab had its experiment schedule, and the life and death of shrimp fit with hydro-social life in the lab. The experiments used shrimp as instrumental tools to understand new diseases and improve commercial products. The most common and routine experiment in the lab was helping shrimp feed companies conduct trials of new feed products. For this work, workers feed shrimp five times per day. After 30 days, they measured their weight and calculated the survival rate of shrimp in each container. By contrast, the purpose of disease challenges and blood testing was to understand how the new shrimp feed and other products enhance the health, immune system, and disease resistance of shrimp. In disease challenges, technicians fed shrimp with poisoned shrimp feed or injected viruses into shrimp. One day in the microbiology lab, Hoa and Lộc, two female technicians were busy extracting bacteria from the nutrition solution and mixing it with shrimp feed and lard. Hoa told me that, from previous experiences, adding lard can coat the bacterial solution within shrimp feed and make sure that shrimp will eat the bacteria rather than it dissolving within the water before being eaten. After an hour, I followed Hoa carrying the poisoned feed to a room. There were six plastic bottles in the room; each bottle contained a shrimp and a small bulk of reef. Hoa was carefully putting the right shrimp feed in the right bottles to establish a control group and an experimental group (Figure 55). Through the experiment, the research team can compare the performance of healthy and ill shrimp under the same shrimp feed so that shrimp feed companies can adjust their ingredient to enhance the immune system of shrimp. Technicians occasionally helped a company take blood and collect hepatopancreas from the shrimp to examine effects of their product. All these works show the instrumental relationship of human-shrimp in the lab. Shrimp were poisoned and killed for the production of scientific knowledge and the development of the shrimp industry.

Figure 55 A poisoned shrimp in a plastic bottle within a dark room
Source: Author

While conducting the disease challenge and blood testing, technicians attuned their bodies to individual shrimps. When technicians were catching shrimp from plastic bottles by a net and their hands, shrimp swam very fast to escape from the net and bounced from their hands. After catching them, technicians pressed the shrimp's tail and injected the virus into the shrimp’s back. The body of whiteleg shrimp became pinker (Figure 56). Technicians developed skills working with animals to ease breed-strain tensions (Greenhough and Roe, 2019). One day, I visited the lab and found Hoa practising taking blood from a black tiger shrimp. She was nervous and worried that she could not draw blood from shrimp successfully, which was one of her upcoming tasks the next Tuesday. Part of her goal in practising was to reduce shrimp’s pain. However, it was not an easy task because shrimp jump when they are scared (the technicians said), and technicians had to find the right place to extract the shrimp's blood. In the actual experiment, she put some anticoagulants into syringes and jabbed the needle into the carapace, somewhere around the third legs of the shrimp. She bent the shrimp and fixed them with her fingers (the act was like Figure 57). While extracting blood, the shrimp moved their walking legs. However, she struggled with drawing blood, and the shrimp suffered longer until other technicians helped her. Through this work, technicians were making sentient shrimp into research samples.

Figure 56 Quang is injecting virus into a whiteleg shrimp
Source: Author

Figure 57 Taking blood from a shrimp

Source: Author

In the lab, the entire body of laboratory animals was unmade, sampled, and remade into pieces of research samples for experiments. After taking blood, Lộc used a knife to dissect the shrimp from their back symmetrically to collect the hepatopancreas (Figure 58). Most of the samples were delivered to customers because they wanted to analyse themselves, and the only experiment technicians did was counting hemocytes and separating serum from the whole blood (or so-called hemolymph) (Figure 59).[24] The other technician dyed the hemocyte and dripped the blood on a slide with the grid. The technician put it under the microscope and counted the dyed hemocyte. It was important to know the number of hemocytes in the shrimp to evaluate their immune system and health status. At the same time, the same test tubes of whole blood were centrifuged. After around 15 minutes, technicians collected serum from tubes and put it into a styrofoam box with ice, which will be delivered to their customers. It was my first time witnessing the experiment of shrimp dissection. I was surprised how the body of shrimp was unmade, shrimp hemocytes became visible, and shrimp serum was refined.

The dramatic scene of blood testing triggered an ethical concern. It was a rare occasion for technicians to kill living shrimp, unlike slowly poisoning shrimp or testing dead shrimp. After finishing the blood testing, Hoa and Lộc asked me in Mandarin: do I think they are cruel? Hoa and Lộc were learning Mandarin and raising this serious topic in their foreign language but my mother tongue to ensure that I could understand the meaning and also softened the atmosphere. My answer was “not at all.” As Sharp (2018: 13) argues, technicians usually monitor death talk in labs and use other words,

[24] Hemocyte is a defence cell in the immune system of invertebrates to fight pathogens.

Figure 58 Dissecting shrimp and collecting their hepatopancreas
Source: Author

Figure 59 The serum of shrimp
Source: Author

such as cull and sacrifice, to replace the word kill. After a while, I also felt uncomfortable with my initial answer. Shrimp, as invertebrate and meat animals, did not gain sympathy, public interest, or ethical concerns within and outside the lab, just like zebrafish in labs (Message and Greenhough, 2019). Moreover, Vietnam does not have any shrimp welfare initiatives and guidelines of 3Rs (Replacement, Reduction, and Refinement). Once, I asked a senior technician, who obtained her master's degree in shrimp disease in Australia and previously worked in the governmental department of animal health, about the ethics and animal welfare of shrimp. She understood my concern but answered that it was not an issue in Vietnam. Even without any regulatory attention, however, technicians were trying to reduce pain and suffering by taking blood precisely and quickly. Animal technicians often face the ethical tension between providing care and harnessing the bodies of laboratory animals for utilitarian ends (Greenhough and Roe, 2019). The ethical concerns are constrained beyond laboratory walls to broader political economies, such as shrimp economies (Johnson, 2015).

In this section, I unpacked hydro-social life for shrimp experiments in an urban laboratory. For conducting research, technicians and workers arranged the living environment for shrimp and observable conditions for experiments. Water-shrimp-human-environment relations are reconfigured for the scientific-based shrimp industry. The knowledge and commodity for biosecurity outside the lab are produced by poisoning and killing shrimp inside the lab.

6.4 Conclusion

This chapter analysed how the laboratory contributes to knowledge production and commodity innovation for biosecurity in shrimp economies. It explored the purposes and effects of testing services by visiting improvised labs, a governmental station and a private lab. It then examined the development and deployment of two anticipatory logics of biosecurity from the lab to the field. Finally, this chapter unpacked hydro-social life for shrimp experiments in Dr Anh's lab by observing the preparation and conduct of the experiment.

First, testing shrimp health and water quality is the basic practice for biosecurity. These testing services are strongly connected with the shrimp industry, such as providing free testing in the retail shop or PCR testing in the governmental station and the private lab. Testing results made algae and bacteria in water visible and pathogens in shrimp legible. Farmers and companies can secure shrimp health and water ecologies by adjusting their pond management and making economic decisions to reduce the risk of shrimp disease.

Second, scientists proposed and deployed two anticipatory logics of biosecurity from the lab to the field: securing shrimp health by pathogen management and immuno-preparedness and using life to manage life in shrimp and water. These two logics have different strategies to manage water-pathogen-shrimp-human-environment relations. The first biosecurity method is industrialising the bodies of shrimp by preventing hereditary infection with SPF shrimp and enhancing the immune system of shrimp with vaccines. However, these two products performed well in the controlled lab but had their limitations in the field, such as environmental infection and the unstable performance and the commercial infeasibility of inoculation. The other method is using probiotics to manage shrimp health and water ecologies. They were applied to pond water and shrimp feed. However, the non-standardised product in the market and the wrong use of probiotics on the shrimp farm made its efficiency questionable. It is worth noting that these biosecurity strategies and biotechnological commodities are developed under the context of capitalist technoculture, which shapes the operation of shrimp economies. However, it still requires the notion of trust and the proper farming practices to deploy biotechnological commodities in the field.

Third, technicians and workers in the lab created a distinctive hydro-social life by making shrimp into laboratory animals and utilising bacteria and viruses for disease challenges. In the experiment, shrimp were kept alive and died for research. Before conducting experiments, technicians and workers construct water-shrimp-human-environment relations into an observable and controllable condition in an urban laboratory. Unlike the logic of biosecurity for disease prevention on the shrimp farm, technicians and workers generated knowledge and innovated the commodity form by intentionally poisoning and killing shrimp. Although these shrimp experiments showed the instrumental relationship between humans and shrimp, technicians aim to reduce the pain and suffering of shrimp by killing them skilfully. These shrimp experiments were for knowledge production and commodity innovation in shrimp economies beyond the lab.

Chapter 7. Conclusion

In Chapter 1, I posed three research questions: (1) How are shrimp economies formed and constructed by capitalist and more-than-capitalist relations? (2) What relations among water, shrimp, and humans take shape across multiple sites? (3) How do shrimp economies affect agrarian, technical, and environmental changes across different types of farmers and capitalists in Vietnam's four kinds of shrimp farming? Drawing on multi-species and multi-sited ethnography, this dissertation has answered these questions by tracing the commodity chain of shrimp across the hatchery, the shrimp farm, and the laboratory within and beyond the Mekong Delta. The overarching argument in this dissertation is that shrimp economies, as a form of bioeconomy, are formed and constructed by organising hydro-social lives within and across different parts of the commodity chain. This chapter concludes by summarising the key arguments, illustrating three main contributions and a methodological contribution, and suggesting three potential directions for future research.

7.1 The key arguments of this research

This section summarises three key arguments made in the dissertation. First, I have argued that shrimp economies are formed and constructed through the combination of capitalist relations, like shrimp domestication and industrial production, and more-than-capitalist relations, such as family kinship, community ties, and gender divisions. Second, I have shown how shrimp economies are organised as hydro-social lives centred on managing water-shrimp-human-environment relations across the hatchery, the shrimp farm, and the laboratory. Third, I have argued that farmers and capitalists practising monoculture and polyculture models of shrimp farming confront different agrarian, technical, and environmental changes, which are interconnected. Across the next three section, I will explain why key arguments in this thesis matter for geographic scholarship.

7.1.1 The formation and construction of shrimp economies

This research argued that shrimp economies as a form of bioeconomy are formed and constructed by the combination of two aspects: (1) the materialities of shrimp production and (2) capitalist and more-than-capitalist relations.

In relation to materiality, shrimp domestication unpacks the life cycle of shrimp and reassembles it by mimicking living environments and enrolling other species into the shrimp industry (see section 4.1). Shrimp aquaculture and its ecological conditions of production have been industrialised by developing socio-technical practices of care (the innovation of SPF shrimp, hatchery systems and shrimp ponds) and managing multi-species relations (shrimp-algae-brine shrimp and shrimp feed) (see section 4.3). However, industrial production (the monoculture model) causes high risks of shrimp diseases and large environmental externalities (see section 5.2). Shrimp excrement and the residues of shrimp feed deteriorate water quality and ecology, turning shrimp ponds into a hotbed for disease. Furthermore, shrimp ponds discharge wastewater with viruses into canals, later used by other farmers downstream. Thus, these spatial relations within and across shrimp economies confront environmental externalities and require biosecurity to care for water-shrimp-human-environment relations to maintain capital accumulation (see section 4.2, 5.2 and Chapter 6). Although some shrimp economies deploy a monoculture model (intensive and super-intensive shrimp farming) on the commodity frontier, there are still other polyculture models (integrated mangrove-shrimp farming and improved extensive shrimp farming) at work diversifying both livelihoods and ecologies in the Mekong Delta (see section 5.1 and 5.2).

At the same time, shrimp economies are underpinned by capitalist and more-than-capitalist relations. Political ecologists have argued that these relations vary across different social contexts and political histories (Stonich and Vandergeest, 2001; Paprocki, 2014; Marks, 2010; Huang, 2015). This research demonstrated capitalist technoculture in the upstream industry and more-than-capitalist relations on the shrimp farm. In the Mekong Delta, the upstream industry, such as larviculture, biotechnological commodities, and shrimp feed industry, are mostly operated by family hatcheries, foreign companies, and research institutes (see section 4.3, 6.2, and 6.3). On-farm production as a high-risk investment is bypassed by large companies and conducted by mostly smallholder farmers and some urban investors, and foreign companies. Large companies do not extend their business to on-farm production but indirectly control the industry by selling industrial shrimp feed or buying shrimp from farmers. Furthermore, foreign shrimp feed companies developed a new business model to ask Vietnamese sales agents to pay them first and gain money back from farmers after shrimp harvesting. Thus, the high-risk investment in the shrimp industry is transferred to smallholder farmers and sales agents. Farmers, investors, and companies developed four kinds of shrimp farming, entangling with capitalist and more-than-capitalist relations, such as family kinship, community ties, and gender divisions (see section 5.1 and 5.2). Capitalist relations mobilise various material elements to make hydro-social lives scalable; more-than-capitalist relations are connected to non-scalable and salvage rhythms, showing diverse livelihoods and ecologies in shrimp economies. More-than-capitalist relations mitigate economic loss from shrimp disease, particularly for small farmers, while lubricating shrimp economies to overcome frictions of capitalist relations in the field. In addition, biotechnological commodities are innovated by scientists in the lab under the context of capitalist technoculture, but they still require more-than-capitalist relations, particularly trust between scientists and farmers, to deploy in the field.

7.1.2 Hydro-social lives within and across three sites

By developing the idea of hydro-social life, I argued that shrimp economies are a form of water-based production that requires assembling and reassembling water-shrimp-human-environment relations across three sites. Shrimp economies have been industrialised by dividing the life cycle of shrimp into three sites for different goals: (1) shrimp reproduction in the hatchery, (2) shrimp growth in the shrimp farm, and (3) scientific research in the laboratory within and beyond the Mekong Delta.

At each site, and in the relations among them, the everyday lives of humans are aligned with the life of shrimp and ecological conditions of production. In the hatchery, hydro-social life is arranged for shrimp reproduction (see section 4.2). Shrimp broodstocks are caught or imported to the hatchery. They live in water of higher salinity. Technicians and workers care for them and create a mating atmosphere for propagating larvae. On the shrimp farm, hydro-social lives are constructed for shrimp growth (see section 5.2). Shrimp are grown in water of lower salinity by farmers, workers, investors, and companies in four kinds of shrimp farming in different parts of the Mekong Delta. These four kinds of shrimp farming are shaped by geographical and historical contexts in the Mekong Delta (see section 5.1). Their hydro-social lives are facilitated and impeded by the spatiality and temporality of the delta itself. In the laboratory, hydro-social life is oriented to knowledge production and commodity innovation. Shrimp and pond water are brought from the field to the lab for testing and experimentation (see section 6.1 and section 6.3). Technicians and workers breed shrimp in observable and controllable conditions. They poison and kill shrimp with viruses and bacteria. These hydro-social lives glue together biological life forms and social forms of life for shrimp economies.

Hydro-social lives in these three phases have their own distinctive features, but they sometimes share similar characteristics and are connected by circulating shrimp, water, scientific knowledge, and biotechnological commodities. Since the 1930s, some hatcheries have operated as a laboratory to study shrimp domestication and design breeding systems across continents (see section 4.1). The research findings in the hatchery are industrialised and deployed to the shrimp farm. Currently, they still follow the lab-level biosecurity to propagate SPF larvae and algae. The hatchery delivers larvae in plastic bags containing water of lower water salinity to the shrimp farm in the Mekong Delta (see section 4.2), driving the industrial growth of shrimp production. The hatchery also provides SPF shrimp as research animals to the laboratory for conducting experiments. The laboratory provides testing services (see section 6.1), and developes biosecurity strategies (pathogen management, immuno-preparedness, and using life to manage life) and biotechnological products (SPF shrimp and probiotics) for the shrimp farm (see section 6.2).

Hydro-social lives in these three sites are embedded in broader physical environments, which profoundly influence water quantity, quality, and ecology. Temporally, water supply in the Mekong Delta is significantly affected by daily, seasonal, and annual variations (see Chapter 5). For instance, improved extensive shrimp farming is based on the seasonal change of water salinity between the rainy and dry season. Farmers in the mangrove forest usually harvest shrimp by utilising the tidal range between their shrimp ponds and the canal during the low tide on the 15th or 30th day of the lunar month. Spatially, farmers, companies, and hatcheries in the Mekong Delta often handle wastewater from upstream by recharging clean seawater during the high tide to secure water quality in their shrimp ponds or shrimp tanks. Hydro-social lives are further entangled with the delta by mobilising both huge infrastructure and small devices to redirect and stabilise water flow and to enhance the maximum amount of shrimp in ponds. In another example, Dr Anh asked water companies to deliver seawater from a coastal city to his urban laboratory every week for breeding shrimp.

These three sites all practised biosecurity to maintain hydro-social lives in ways that foster capital accumulation and disease control. The logics of biosecurity focus on either each element in water-pathogen-shrimp-human-environment relations or relations among them. One biosecurity strategy is managing shrimp health through pathogen management and immuno-preparedness. The hatchery and the shrimp farm often test shrimp (broodstocks, larvae, and shrimp) to confirm their pathogen-free status in the laboratory before the transaction (see section 6.1). In Dr Anh's hatchery and other companies' hatcheries, they always tested shrimp's food before feeding broodstocks and larvae (see section 4.2). The other biosecurity strategy is using life to manage life. Managing aquatic animal health means managing water with viruses, bacteria, nitrogen, and other life forms (cf. Helmreich, 2011). All these three sites usually manage water quality and water ecologies before breeding shrimp. Currently, scientists, some farmers, and shrimp feed companies are advancing their pond management by using probiotics to increase good germs and depressing bad germs in pond water and shrimp intestines (see section 6.2). They want to create microbial symbiosis to avoid the formation of disease situations. Biosecurity not only aims to secure shrimp life as a commodity but also shapes the development of the shrimp industry. For instance, SPF black tiger shrimp and blue shrimp were interbred as new biotechnology products to reconstruct the shrimp market. These logics of biosecurity still need to be examined in the field, where hydro-social lives are embedded in more environmental and economic uncertainties.

However, biosecurity is unevenly distributed across three sites owing to different hydro-social lives, such as environmental uncertainties and commercial interests. The hatchery and the laboratory usually arrange their buildings in a well-controlled environment to achieve a high level of biosecurity. By contrast, the shrimp farm in the Mekong Delta confronts more uncertainties from the environment (see section 5.2). The biotechnology products innovated in the lab do not always work well on the shrimp farm. SPF shrimp only signifies current health status but still might become infected on the shrimp farm. It requires PCR testing results to guarantee the shrimp's health and trust between sellers and buyers to secure the reputation of new SPF shrimp. Furthermore, farmers and companies can also innovate biosecurity practices by designing shrimp ponds and adjusting pond management rather than unilaterally learning biosecurity from the lab. Due to high stock density, the monoculture model of shrimp farming is exposed to a higher risk of shrimp disease. They need to discharge water and clean up the sludge regularly. In super-intensive shrimp farming, urban investors and foreign companies installed plastic mats and protein skimmers to detach water from soil and control water quality. Nevertheless, polyculture shrimp farming breeds shrimp at lower densities so that they have a lower risk of shrimp disease and do not adopt further biosecurity practices.

7.1.3 The social and geographical differentiation of agrarian, technical, and social changes

This research argued that farmers and capitalists in different kinds of shrimp farming are unevenly affected by agrarian, technical, and environmental changes. These changes in shrimp economies are interconnected and influence each other on the commodity frontier. This research has investigated the social and geographical differentiation of agrarian, technical, and environmental changes caused by shrimp economies through contextualising the four forms of shrimp farming in the Mekong Delta. Shrimp farming is mobilised for economic development and poverty alleviation but is constrained by land-use planning and state regulation.

The monoculture model of shrimp farming, like intensive and super-intensive shrimp farming, causes drastic changes to farmers and capitalists (see section 4.3, 5.2, and 5.3). The Vietnamese government proposed intensive shrimp farming as a poverty alleviation project for the Khmer minority in the Mekong Delta. However, Khmer farmers often confront the economic loss of shrimp disease. From my fieldwork, I found farmers tackle the economic challenge by selling ill shrimp before they die, planting other crops, working in cities, and receiving international remittances through family kinship networks. Other farmers borrow money from shrimp traders or sales agents, which forms a debt-creditor relation in shrimp economies. Due to wastewater problems and the high risk of shrimp disease, some farmers with enough capital, urban elites, and foreign capitalists upgrade their shrimp ponds into super-intensive shrimp farming, following a two-stage production model to manage water-shrimp-human-environment relations. Super-intensive shrimp farming has a higher stock density of shrimp and brings more shrimp feed from sales agents. Furthermore, sales agents help bankrupted farmers upgrade their shrimp ponds into super-intensive shrimp ponds with better biosecurity to solve debt problems and accrue future profits. However, super-intensive shrimp farming discharges more wastewater and causes more environmental problems. Thus, local governments started to monitor wastewater treatment in super-intensive shrimp farming. However, the lack of private and public investment in water systems still exposes smallholder farmers to water pollution.

The polyculture model of shrimp farming has a different social and geographical differentiation (see section 5.1.1 and 5.1.2). The integrated mangrove-shrimp farming was formed and flourished in the ruins of forestry in Cà Mau for two reasons. The mission of FMBs shifted from lumbering to mangrove restoration, which involved working with farmers. Meanwhile, the international NGO CfM introduced the idea of organic shrimp and ecosystem services into Cà Mau. These policies and action plans encourage farmers to breed black tiger shrimp naturally and restore mangroves. In the other case, farmers at the boundary between freshwater and saline water in the Mekong Delta are encouraged to practise the model of improved extensive shrimp farming (rotational polyculture) by breeding black tiger shrimp in the dry season and growing rice and breeding giant freshwater shrimp in the rainy season. It requires the Department of Hydraulic Infrastructure to manage water quality in canals by opening and closing sluice gates. The seasonal change in land use shapes the microbes in the soil and reduces the risk of shrimp disease. These two types of shrimp farming rely more on food chains in the ecological system and fewer inputs of capital and labour.

These agrarian, technical, and environmental changes are shaped by the upstream and downstream industries with uneven power relations. Although shrimp are mostly grown by farmers and investors, the larvae, shrimp feed, shrimp price, and biosecurity services are controlled by the upstream and downstream industries (hatcheries, shrimp feed companies, sales agents, shrimp traders, and research institutes). These social organisations also affect these three kinds of changes through knowledge production, commodity innovation, and price-setting (see section 4.3, 5.3 and 6.2). For example, farmers and investors in the monoculture model spend significant money in buying shrimp feed. Shrimp farmers and investors do not have the power to determine transaction prices but could only compare shrimp prices provided by shrimp buyers with price sheets. Their knowledge, commodities, and price sheets need to circulate and fit with hydro-social lives in the field.

7.2 Learning from shrimp economies in the Mekong Delta

To this end, this research has made three theoretical, geographic contributions to political economy, political ecology, water research, delta studies, and STS. In addition, it also makes a methodological contribution to the literature on fieldwork experience in authoritarian Vietnam.

7.2.1 The socio-natural organisation of commodity production in political economy and political ecology

This research contributes to political economy and political ecology by unpacking the socio-natural organisation of commodity production across multiple sites. It enriches discussions of shrimp aquaculture by extending the research focus from crustacean capitalism on the shrimp farm to shrimp economies across the hatchery, the farm, and the laboratory. Political ecologists have analysed the material condition and production relations of shrimp aquaculture on the shrimp farm (Stonich and Vandergeest, 2001; Paprocki, 2014; Marks, 2010; Huang, 2015). This thesis visited the upstream industry and other supporting industries, like the hatchery, algae and brine shrimp production, shrimp feed companies and the laboratory, to capture the multiplicity of hydro-social life across sites in which shrimp economies are constituted. This research focus is also a touch of concern in economic geography. It is crucial for economic geography to analyse how the social-natural organisation of commodity production is divided into several sectors and then linked together as an industry, in which environmental change is integrated into economic activity (Bridge, 2008). Current studies have also noticed the critical role of the hatchery and the biotechnology industry, or so-called industrialising organisms, in the development of marine aquaculture (Hinchliffe et al., 2016, 2018, 2020; Banoub et al., 2020). Shrimp aquaculture is a scientific-based industry that is tied to shrimp pathology, a commercially-driven discipline. Furthermore, this thesis captured capitalist and more-than-capitalist relations that support the formation of operation of shrimp economies. It echoes that economic geography should strive to depict both the coherence of capitalism and the diversity of more-than-capitalist worlds (Bridge, 2008).

This research pushed discussions in the social-natural organisation of commodity production further by conducting historical analysis and participatory observation in the hatchery, the laboratory, and other supporting industries. The historical analysis revealed that shrimp domestication and industrial (re)production are developed with a set of techno-scientific practices and multi-species relations across continents to achieve the commercial scale. The participatory observation showed that the upstream and supporting industry are developed under the context of capitalist technoculture, while they still require more-than-capitalist relations to deploy their biotechnological commodities on the shrimp farm.

7.2.2 Bringing water research into bioeconomies

This thesis has brought water research into the topic of bioeconomies by bringing together social lives and shrimp lives within the notion of hydro-social life. Aquaculture is a water-based industry, and water is integral to shrimp commodity production (Lien, 2020). Caring for aquatic animals requires caring for the water (Gaard, 2001; Merchant, 1997). This thesis told stories of water-meets-worlds rather than the narrative of water-meets-modernity with the notion of hydro-social life in the context of shrimp economies. It developed hydro-social life by the writing of water-shrimp-human-environment relations to answer two fundamental questions in water research: what is water? How does water fit with society? This writing shows that the ontology of water is multiplied across the commodity chain of shrimp aquaculture. Multiple ontologies of water broadened the research focus from freshwater to water with chemical compounds (like salts) and species (cf. Yates et al., 2017). At the same time, contextualising hydro-social lives in shrimp economies showed that water and shrimp meet worlds with diverse forms of life, such as gender divisions, family kinship, and community ties. These diverse forms of life are mobilised to construct and secure water-shrimp-human-environment relations for maintaining capital accumulation and avoiding shrimp disease. In other words, hydro-social life contributes to the discussion of biosecurity by tracing how water and its relations with other species are maintained or adjusted across different sites.

7.2.3 Multi-species relations in delta studies and STS

This research has contributed to delta studies and STS by critically unfolding hydro-social life in the hatchery, the delta, and the laboratory. It developed delta studies by observing four kinds of shrimp farming with farmers and capitalists in different parts of the delta (cf. Krause, 2018, 2018; Krause and Harris, 2021). It showed how the spatiality and temporality of the delta shape commodity production and, in turn, are shaped by devices and infrastructure (cf. Morita, 2017; Morita and Jensen, 2017; Morita and Suzuki, 2019). This finding is crucial for delta studies to understand the tension between two perspectives: delta as a capricious environment and as an infrastructure object. In addition, it linked together delta studies, water research, and economic geography by examining the characteristics of the amphibious deltaic environment and the management of freshwater and saline water, which shape the operation of shrimp economies (cf. Bridge, 2008).

As for STS, this research provided a rich account of knowledge production and commodity innovation via laboratory ethnography. It is important for economic geographers to understand the role of labs and their influence in the socio-natural organisation of commodity production. The laboratory is a critical site for the biosecurity of animal industries (Keck, 2015; Hinchliffe et al., 2016; Blanchette, 2020). The laboratory develops pathogen-based approaches or anticipatory logics for biosecurity by focusing on shrimp and water ecologies or their relations in hydro-social lives. Knowledge production and commodity innovation in the lab are economic activities that shape hydro-social lives in the field. This research also contributes in particular to recent work in laboratory animal studies, focusing on ethical principles and the everyday care of laboratory animals by observing shrimp (wet) labs in the Global South (cf. Johnson, 2015; Greenhough and Roe, 2019; Message and Greenhough, 2019).

7.2.4 A foreign researcher working in authoritarian Vietnam

My fieldwork experience also contributes to the literature on fieldwork experiences in authoritarian countries, especially in Vietnamese studies, by providing a guideline for research application and reflecting my positionality in the field. Although it is hard for others to fully replicate my fieldwork experience, the experience is still valuable for understanding the procedure for applying for a research visa and research permits, managing the power relationship with local governments, and organising the research team (gatekeepers, civil servants, translators, and research assistants). In this research, I also reflected on how my national and gender identity (as a Taiwanese male PhD student) influenced power relations with informants.

7.3 Future research

I suggest three potential directions for future research by connecting some empirical fragments from my fieldnotes with theoretical concepts. First, I suggest that theoretical concepts can be extended by comparing economic activities and regional development in the deltaic environment. Second, the role of the authoritarian state should be developed further to link political ecology with political geography and critical geopolitics. Third, I suggest that mangrove restoration can provide other possibilities for researching bioeconomies.

7.3.1 Delta comparison

Delta comparison can be a research method for extending delta studies. By focusing on

Vietnam, this research has implicitly compared the industrial structure and social relations in shrimp economies in Vietnam with those in Thailand, Bangladesh, and Central America (Chapter 2 & 5). This comparison can be foregrounded in the future with further fieldwork in other deltas. Delta comparison can examine how far shrimp economies and hydro-social life can travel and be retheorised in other deltaic environments (Krause, 2018; Krause and Harris, 2021).

The process of delta comparison can be operationalised by learning from regional studies. In regional studies, Roy (2009) suggests that scholars should describe traits of a place but also trace how a place links to others. Every place has its own specific issues reflecting certain geographical and historical contexts. By focusing on shrimp economies and hydro-social life, this research showed how the Mekong Delta was profoundly affected by national reforestation policy, climate change adaptation plans, and cross border river governance. On the other hand, certain ideas and concepts are formed in particular world-areas, and researchers need to trace how these ideas and concepts travel to other places. This thesis mentioned the role of Dutch experts and how Dutch experience was introduced and incorporated into *The Mekong Delta Plan*. During my fieldwork, I noticed that the Dutch and Vietnamese experiences are a process of co-learning (Hasen et al., 2019). Vietnamese scholars and researchers at WACC, my host institute in Vietnam, were mostly trained by Dutch universities. They obtained their doctoral and master's degrees in the Netherlands. Coming back to Vietnam, they built up partnerships with Dutch research institutes or consulting companies in water governance in the Mekong Delta. In addition, they also hosted many Dutch postgraduate students and assisted them in conducting fieldwork in the Mekong Delta. Instead of considering delta studies as context-specific studies, with this relational thinking, researchers could enrich our understanding of wetness, rhythms, and volatility in particular regions and link them to others. Thus, future research can compare delta studies with a relational perspective and generalised conditions and issues within deltas.

7.3.2 The role of an authoritarian state in shrimp economies and water management

Loftus (2020) calls for political ecologists to have more dialogue with political geography and critical geopolitics to explore, for example, how states are involved in environmental issues and how states influence geopolitical ecologies. This research has mentioned how state policies — such as aquaculture programmes, poverty alleviation projects, and the afforestation policy — facilitated and impeded shrimp economies in different parts of the Mekong Delta (Chapter 1 & 5). Although I interviewed civil servants about practices of water management and land-use planning and reviewed state policies in Cà Mau coastal area and a minority community, I did not systematically analyse how state policies shifted from growing rice to breeding shrimp in the Mekong Delta on a regional scale.

Vietnam is a socialist and authoritarian state but shares many things in common with other developmental states in East Asia, particularly China. Socialist and developmental states (in East Asia) usually have industrial policies to guide and stimulate economic development (cf. Morris-Jung, 2022). For instance, the central government in Vietnam usually sets up economic indices and production quotas, and local governments have to meet the goals. In China and Vietnam, political institutions are designed for upward accountability: local governments are responsible for the central government but not the people (see Chien, 2010, 2015). Thus, local governments usually attempt to meet the economic goal. In 2019, I interviewed the project manager of CfM; she told me that the Cà Mau government needed to produce 3 billion tons of shrimp this year. However, in August 2019, the total amount of shrimp production was only 1 billion tons, and the Cà Mau government needs to produce 2 billion tons within four months. Due to limited data availability, I did not have a chance to collect the economic indices and production quotas set by the Vietnamese government.

The other example is the planning and construction of hydraulic infrastructure. Unlike the neoliberal model of stream restoration driven by amateur hydrologists in America, the Vietnamese government is the main actor in planning and regulating the hydraulic infrastructure (Benedikter, 2014a; Lave et al., 2010). However, the Vietnamese government does not have enough capacity to complete all planned projects so that construction projects are currently being outsourced to private companies or other foreign consultants, particularly Dutch experts (Hasan et al., 2019). Furthermore, states are heterogenous entities with ministries and departments to conduct different tasks. Different departments within the government have different goals and priorities, leading to conflictive relations. For example, the Cà Mau government supported environmental protection and developed their own sustainable plan, but they also needed to fulfil the required quota of shrimp production assigned by the central government. Therefore, the agricultural, aquaculture and irrigation sectors sometimes work together. However, they also need to develop intensive shrimp farming because it significantly produces more shrimp than mangrove-shrimp farming. We can understand the role of authoritarian and developmental states in water and environmental governance by analysing relations among state, companies, and foreign experts in the Mekong Delta.

7.3.3 Other possibilities in bioeconomies

This research has analysed multi-species relations across the hatchery, the delta, and the laboratory. However, most of these multi-species relations are instrumental relationships dominated by humans. Even though socio-technical practices of care for shrimp and water ecologies can temporarily suspend the instrumental relationship, shrimp in the end are still a commodity for shrimp economies. If we shift our focus to mangrove restoration, it might provide other possibilities for researching bioeconomies, in which nonhumans are not fully controlled and dominated by humans.

Integrated mangrove-shrimp farming might provide other possibilities in bioeconomies by foregrounding wildlife restoration. This research has analysed how the shifting role of Forest Management Boards changed the forestry industry and farmers' livelihoods in Cà Mau (see Chapter 5). However, due to governmental regulations on foreign researchers, I was not allowed to stay in the restricted area to conduct a longer period of research in Cà Mau. Shrimp are only one of the species to arise from the ruins of forestry and the effort to restore mangrove forests. It may be worth analysing multi-species relations among mangrove-shrimp-other species, and power relations among French colonists, national forest enterprises and Vietnamese farmers. Archive analysis and storytelling can capture the thickly textured history of these relations, from French colonialism, socialist economy and economic reforms, to climate adaptation.

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