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Shrimp Economies and Hydrosocial Lives in the Vietnamese Mekong Delta

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ABSTRACT: Shrimp economies in the Vietnamese Mekong Delta are a form of economic, political, and infrastructural project undertaken to address saline water intrusion and increase access to international markets. This paper examines shrimp farming in this region using the concept of hydrosocial life to analyse how water is entangled with life forms and forms of life in bioeconomies from two angles: (1) the ecological conditions of production and (2) agrarian, technical, and environmental changes in the delta. It does so using delta methods, comparing four kinds of shrimp farming: integrated mangrove-shrimp farming, alternating rice-shrimp farming, intensive shrimp farming, and super-intensive shrimp farming. All are conducted by various stakeholders in the rainy and dry seasons and in different parts of the Mekong Delta. This paper argues that shrimp farming organises hydrosocial lives by constructing ecological conditions of production, which are both supported and constrained by the delta as a turbulent environment and an infrastructuralised object. Each kind of shrimp farming requires a distinctive hydrosocial life, imposing uneven impacts on the everyday lives of farmers, workers, and entrepreneurs and producing agrarian transformations, technical development, and environmental changes. Shrimp breeders shift between these four types of shrimp farming in response to household income needs, biosecurity concerns, and policy measures. This paper extends water research and delta studies by exploring relationships between water, life, and economies in a deltaic environment.

KEYWORDS: Shrimp, disease, hydrosocial life, ecological conditions of production, Vietnamese Mekong Delta

INTRODUCTION

Climate change and salinity intrusion have resulted in heightened salinity levels in the Vietnamese Mekong Delta for more than six months each year, killing rice seedlings and exacerbating rural poverty (Toan, 2014). Since 2010, the Vietnamese government has worked with international experts and the government of the Netherlands to improve the country's adaptation capacity to climate change through the development and implementation of the *Mekong Delta Plan*.[1] Meanwhile, the Vietnamese government is opposed to the construction of additional dams along the main Mekong flow by upstream countries, as such projects would exacerbate dry season salinity intrusion and coastal erosion (Biggs et al., 2009: 211). The Vietnamese government (2022) announced *The National Aquaculture Development Program For The Period Of 2021-2030* (Decision No. 985/QD-TTg) to raise the status of shrimp farming in the Vietnamese Mekong Delta and boost shrimp exports by improving access to international markets (Nguyen et al., 2019). From 1995 to 2017, production from shrimp aquaculture in the Vietnamese

[1] Dutch experts and the government of the Netherlands have provided engineering and water management assistance and guidance to Vietnam on multiple occasions (Hasan et al., 2019; Weger, 2019). Vietnamese and Dutch 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 resource management and land use planning under a wide range of socio-economic scenarios (Netherlands Delta Commission, 2013). The Mekong Delta Plan stresses similarities in the vulnerability to flooding in the two countries and proposes adapting the Netherlands' experience to Vietnam.

Mekong Delta increased twelve-fold, from 47,121 to 598,690 tonnes (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-Brahmaputra-Meghna Delta.

However, putting these environmental and economic changes in a broader geographical-historical context shows that the transformation of rice and shrimp farming is not only a climate adaptation strategy but also an economic, political, and infrastructural project that has developed in the Mekong River Basin over the past 20 years (Gorman, 2020). The narrative of shrimp farming as an adaptation strategy for climate change and saline water intrusion is actually a contingency plan embedded in the existing political-economic structure (Paprocki, 2018, 2019, 2021). In this sense, shrimp farming is just the latest in a long history of adaptations in which the Vietnamese Mekong Delta has become a resource frontier (Middleton, 2022). Since the 1950s, the Mekong River Basin has been investigated, planned, and harnessed by the US, China, and the Mekong countries under conditions of geopolitical contestation (Molle et al., 2009).

The end of the Vietnam War in 1975 left the country diplomatically isolated and unable to import rice. In the 1980s, the Vietnamese government promoted a 'rice first' policy aimed at ensuring domestic food security (Nguyen et al., 2020a). This policy involved increasing farmland through the construction of embankments along various tributaries of the Mekong River and the coastline and the conversion of saline regions into farmland through the building of perennial irrigation and drainage systems (Perlez, 2016). As a result, the Vietnamese Mekong Delta was transformed from a 'river-water' society into a 'hydraulic society' in an effort to meet domestic rice demand (Evers and Benedikter, 2009; Reis, 2012). After *đổi mới* (market reforms) in 1986, export-oriented aquaculture such as catfish and shrimp farming appeared in the coastal areas of the Vietnamese Mekong Delta. However, shrimp farming has proven a risky undertaking for farmers and investors, and shrimp disease outbreaks frequently result in massive debt and financial ruin (Nguyễn, 2024).[2] The geographical expansion of shrimp economies in this frontier space has reshaped the biophysical characteristics of shrimp and remade delta ecologies. In short, commercial shrimp farming is significantly shaping agrarian, technical, and environmental changes in the delta.

This paper examines shrimp farming through the lens of hydrosocial life to explore how water is entangled with both 'life forms' and 'forms of life' in bioeconomies. The first section introduces the notion of hydrosocial life by reviewing the linkages between water, life, and economies and nesting hydrosocial life within delta studies. The following section advances a unique research method – 'delta methods' – by comparing four kinds of shrimp farming in different spatialities, temporalities, and social positionalities in the delta. This study then analyses how the shrimp pond – the basic unit for shrimp farming – is constructed by shrimp growers and affected by the delta to underpin or impede ecological conditions of production. Furthermore, this study explores how shrimp farming has caused uneven agrarian transformations, technical developments, and environmental changes in different forms of hydrosocial life. This leads us to demonstrate the dynamism of the delta by examining transitions and tensions among different types of shrimp farming. Finally, this paper concludes by focusing on the relations between water, life, and economies in the delta in order to extend the scope of water research and delta studies.

[2] In 2014, an official in Bình Đại county, Bến Tre Province mentioned that shrimp disease caused losses of around 50 million Vietnamese đồng. Miss Thuy Linh, a farmer, also said that her family has stopped shrimp breeding on her 5-hectare farm because of an outbreak of shrimp disease. The leader of the Thạnh Trị district has described the impact of multi-year disease outbreaks on local shrimp farmers (Nguyễn, 2024).

HYDROSOCIAL LIFE IN DELTA ENVIRONMENTS

Hydrosocial life: Linking water and life together

Water quantity, quality, and ecology constitute the ecological conditions of shrimp production. Human geographers recognise that water is always internally articulated with economic, social, cultural, and political relations as part of hydrosocial processes (Bakker, 2004; Linton and Budds, 2014; Swyngedouw, 2015; Liao and Schmidt, 2023). The concept of hydrosociality was developed to analyse socionatural relations in the circulation of water (Swyngedouw, 2004; Kaika, 2005; Gandy, 2014; Boelens et al., 2016).[3] The reading of water as a hybrid object and nonhuman actant rather than a passive object in hydrosociality is influenced by the early work of Bruno Latour and Donna Haraway on hybrid objects and the cyborg manifesto (Haraway, 1991; Latour, 1993). Latour (1993: 53-54) rejects treating objects, things, and goods as merely a white screen onto which social scientists can project social categories, nor should they be considered 'hard facts' that social scientists ought to cede to natural scientists. Instead, Latour (1993: 137-138) proposes that researchers should recognise materiality and the agency of things in constituting the world. Echoing Latour's emphasis on material agency, Haraway (1991: 154) argues that humans are hybrids and cyborgs, because humans have already created joint kinships with elements, animals, and machines through the development of scientific knowledge and by making artifacts and technologies. Thus, social scientists need to engage with science, technology, and earth systems in order to understand how water actively impacts human lives.

This paper suggests that hydrosocial scholarship can extend the discussion of water and life by drawing on Haraway's work on companion species. In *When Species Meet*, Haraway (2007: 3) argues that humans and animals are always 'becoming with' each other to form symbiotic relationships; she rejects human independence from the surrounding ecosystem. Thus, this paper argues that the existence of humans, water, and aquatic animals are always entangled, while their coexistence is determined by different practices. Shrimp growers align their lives with the lives of shrimp, within larger hydrosocial lives.

Drawing on the concept of hydrosociality in water research, this paper extends the concept of 'hydrosocial life' (or 'worlds'), proposed by Franz Krause (2018), to examine how water is entangled with social and physical processes at the intersection of the water cycle and bioeconomies. This paper argues that water is the ecological condition of production and requires meticulous management for capital accumulation and disease prevention. Hydrosocial life conceptually brings together biological life forms and social forms of life in bioeconomies. The notion of 'life form' means an organism with physical, metabolic, and ecological possibilities, while 'form of life' refers to the social and cultural ways of thinking and acting in a more-than-human society (Helmreich, 2009; Helmreich and Roosth, 2015). Schmidt (2017) argues that we learn to manage water through judgments and practices that fit with our forms of life such as economic activities, social norms, technical criteria, and cultural practices. For example, in aquaculture, humans experimentally modify the growth rate of shrimp using different water qualities and ecological conditions along with water management practices. In other words, water straddles social forms of life and the conditions for multiple life forms. The concept of hydrosocial life emphasises that understanding bioeconomies requires engaging with their underlying biophysical and social worlds.

[3] Although these two approaches are grounded in different ontologies, epistemologies, and methodologies, Wesselink et al. (2017) suggest that they can still effectively collaborate by engaging with one another's narratives. Narratives help elucidate complex phenomena by providing clear causation, a climax, and a resolution. This research proposes hydrosocial life as a way of framing such narratives.

Organising hydrosocial life for shrimp economies

Hydrosocial life is constructed by arranging ecological conditions of production and social relations to support shrimp aquaculture for economic purposes (Liao, 2024). 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 and can refer to different ideas in policy and scholarly circles,[4] Birch (2018: 69-70) suggests that researchers should examine social and environmental processes underpinning bioeconomy and its outcomes. In their classic work, *Violence, Environment, and Industrial Shrimp Farming*, Stonich and Vandergeest (2001) propose a general equation for shrimp economies wherein shrimp are a commodity and land, ponds, and equipment are the means of production. For example, the size of shrimp containment ponds and their stock intensity are related to the availability of land, credit, and labour. Pond size depends on capital investment and access to land. Higher stock intensity requires greater inputs of shrimp feed, which is the main expense of shrimp farming. The size of shrimp in turn determines their price.

However, these equations often face three economic and ecological contradictions caused by pathogens and disease, which are inseparable biological components in the agrarian world (Huang, 2015; Lien, 2015; Bustos-Gallardo and Irarrazaval, 2016). First, longer breeding periods in shrimp ponds increase shrimp weight but also increase the risk of disease. Second, higher shrimp densities in ponds yield a higher return on capital but also increase the risk of contagion. Third, a higher spatial concentration of shrimp farms can reduce production costs but cause ecological exhaustion. Resulting from tensions between economies of scale and environmental carrying capacities, these contradictions can often be mitigated and managed by effective care and preventative practices.

Harbers observes that "care is a substantial component of the farming economy" (2010: 156), since care practices on farms are often designed to optimise economic profits and reduce potential risks. Yet care practices can be ambivalent, entangled with suffering, and deeply embedded in power relations; thus they do not necessarily prioritise animal wellbeing (de la Bellacasa, 2017). How care is offered, to whom and by whom, and through which modalities, are all vital questions (Mol et al., 2010). As in the poultry and livestock industries, aquaculture actors include farmers, workers, and entrepreneurs who deeply care for their farm animals and their living environments (Mol et al., 2010; Porter, 2019; Blanchette, 2020; Lien and Pálsson, 2021). In the breeding process for aquatic animals, farmers, scientists, and entrepreneurs unpack the animals' life cycle and industrialise their living environments through care practices and technology development. Shrimp are propagated in seawater hatcheries and bred by farmers in brackish water in ponds. By contrast, in salmon aquaculture, smolts are reproduced in freshwater hatcheries and then transported to saltwater salmon farms in fjords (Lien, 2015: 30). To give a more familiar illustration, in *Lawn People*, Robbins (2007: 34-38, 43, 94) argues that lawns need a lot of care from lawn owners because turfgrass morphology and its growth cycles (e.g. seasonal changes and inter-annual fluctuations) regularly require significant labour to water and fertilise grasses and kill pests. Similarly, in aquaculture, farmers carefully breed shrimp and salmon by monitoring environmental factors, including oxygen and water temperature (cf. Swanson, 2022). In shrimp aquaculture, farmers care for shrimp, which they regard as property that will be transformed into commodities through harvesting. In other words, care practices in shrimp farming are primarily instrumental and profit-oriented.

[4] Bugge et al. (2016) identify three distinct visions in the bioeconomy literature: biotechnology vision, bioresource vision, and biecology vision. The biotechnology vision focuses on the application and commercialisation of biotechnology. The bioresource vision emphasises how scientific research is applied in raw material sectors, like agriculture, fisheries, and bioenergy, to achieve industry upgrades. The bioecology vision is interested in ecological processes in relation to production conditions such as the optimum use of resources and environmental degradation. This paper examines social and ecological conditions for shrimp production through the lens of the bio-ecology vision.

The care practices of shrimp breeders are often structured by supporting industries such as the biotechnology, service, and equipment industries. Many aquaculture researchers have highlighted how farmers and scientists mobilise a range of products and equipment such as tanks, shrimp feed, and oxygenation systems to maintain a high-density breeding model and increase survival rates (Lien, 2015; Swanson, 2022). These products and equipment are often developed or modified to meet or expand upon existing market demand. Robbins (2007) pointed out that lawn owners often apply pesticides and herbicides to maintain their lawns. The chemical formulations of these products are constantly adjusted by agrochemical companies in response to emerging pesticide-resistant insects and growing public health concerns associated with these chemicals. Similarly, in shrimp aquaculture, shrimp feed companies and their sales agents often promote new pond designs to minimise the risk of shrimp disease outbreaks, thereby expanding their feed market share.

Nesting shrimp economies and hydrosocial lives in the delta

In recent years, the delta has become a research focus to analyse the hydrosocial life-world at the intersection of humans and nonhumans, waters and land, seawater and freshwater (Jensen, 2017; Krause, 2017). Researchers have increasingly turned to 'delta studies' to explore how people organise their lives (with respect to other species) around water in the deltaic environment. Shrimp economies and hydrosocial life should be understood within this context since shrimp aquaculture is often situated at the interface of land and sea as well as salt- and freshwater systems, particularly in the deltaic environment. Many environmental geographers have analysed how shrimp farming influences farmers' livelihoods and causes environmental degradation on shrimp farms and the surrounding environment (Vandergeest et al., 1999; Goss et al., 2001; Marks, 2010; Ha et al., 2013a; Huang, 2015). However, these studies focus more on agrarian changes caused by shrimp aquaculture and rarely consider how the delta itself plays a critical role in shrimp production. Therefore, delta studies provide us with insights into a dynamic landscape and its risks and opportunities under agrarian and environmental changes (Morita, 2017a; Morita and Jensen, 2017; Krause and Harris, 2021; Cons, 2025).

The present research is informed by three key insights from delta studies on how to read these amphibious environments. 1) 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). 2) Delta as a turbulent environment: Scholars treat deltas as unstable and vulnerable landscapes due to shifting river courses and the proximity of wetlands (Biggs, 2012; Lahiri-Dutt and Samanta, 2013). Scholars have also noted how wet and dry seasons, seasonal flooding, and variations of salinity influence farmers' livelihoods (Shinn et al., 2014; Hoque et al., 2017, 2018). 3) Delta as an infrastructuralised object: In this approach, scholars have identified how both the state and residents install devices and construct infrastructure in the delta to engineer and stabilise the deltaic landscape (Biggs, 2012; Bhattacharyya, 2019). 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, and irrigation and drainage systems – under various social and political contexts (Ward, 2001; Muehlmann, 2013; Barnes, 2014; Benedikter, 2014a; Morita, 2016). Reading the delta as either a turbulent environment or an infrastructuralised object – or both – rather than simply as a backdrop brings the background into the foreground (Hetherington, 2019: 6). These two perspectives also exist in mutual tension (Scaramelli, 2021). On the one hand, humans objectify and infrastructuralise deltas as natural resources that can be tamed and exploited. On the other hand, the scale and materiality of the delta such as sediment and salinity, could impede efforts to infrastructuralise the delta (cf. Anand, 2023).

Deltas facilitate and impede ecological conditions of production for shrimp farming in multiple ways. Shrimp farming is embedded in the wetness, rhythms, and volatility of deltas. First, the notion of wetness captures fluid and dynamic worlds (see Lahiri-Dutt and Samanta, 2013; Steinberg and Peters, 2015; Whitt, 2018b; Bhattacharyya, 2019; Krause, 2021). Amphibious landscapes are dynamic, requiring their inhabitants to adjust their lives to fit 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 describes the rapid changes and movements in both social and material configurations. Whereas rhythms refer to cyclical long-term fluctuations, volatility emphasises unpredictable short-term changes. The rhythms and volatility of both nature and economies constantly interfere with each other. When rhythms and economies – irregularly disrupted by volatility – are not in synch, economic and environmental crisis can result (see Whitt, 2018a).

Meanwhile, shrimp economies shape the deltaic environment into a production site through the installation of water management devices and infrastructure, shaping the delta environment into more productive land even as the temporality and spatiality of the delta shape shrimp economies (Furlong, 2010). At a regional scale, the state constructs and manages hydraulic infrastructure such as canals and sluice gates (Evers and Benedikter, 2009; Benedikter, 2014b). At the local scale, farmers and businesses install small-scale devices to manage water quantity, quality, and ecology (Gasmi et al., 2024). Such infrastructure and devices are mediums through which humans construct nonhuman habitats, facilitate certain behaviours, and manage desirable interspecies relations (Morita, 2017b; Barua, 2021). Furthermore, the deployment of such devices and infrastructure shows how human and nonhuman relations are produced and sustained in the hydrosocial cycle (Swyngedouw, 2015: 30).

DELTA METHODS

Delta studies propose delta methods as a situated approach to capture the unique spatial and temporal dynamics of the deltaic environment, including wetness, rhythmic patterns, and volatile changes (Morita and Suzuki, 2019; Krause and Harris, 2021). Rather than simply a toolbox of methods that can be used independent of the empirical context, delta methods require an understanding of the particular features of deltas (Krause, 2018). Thus, this paper uses participatory observation and semi-structured interviews in the deltaic environment to compare four kinds of commercial shrimp farming – integrated mangrove-shrimp farming, alternating rice-shrimp farming, intensive shrimp farming, and super-intensive shrimp farming – in Vietnam's Cà Mau, Bạc Liêu, Sóc Trăng, and Bến Tre provinces during the rainy and dry seasons.

These four categories are based on farming practices, stock density, and the arrangement of shrimp ponds, and they are frequently mentioned in news articles, investment and policy reports for market information, and climate adaptation action plans by governmental research institutes, seafood business investors, and related media (e.g. Tạp chí Thủy Sản, a Vietnam-based magazine focused on aquaculture and fisheries) (Ha et al., 2013a; Seafood Trade, 2019). Shrimp farming models in Vietnam can be categorised in various ways such as distinguishing intensive and super-intensive shrimp farming by their breeding stages, or alternative shrimp farming by its breeding alongside other species. However, this approach to categorisation does not provide adequate scope for theoretical contributions to the notion of hydrosocial life.

Data collection performance in the delta significantly depends on the physical and social positionality of the researchers involved. Delta landscapes cover vast expanses that dwarf the scale of individual humans, who cannot hope to directly observe holistic change at the landscape scale and can only partially experience natural forces (Morita and Suzuki, 2019). This fundamental difficulty in researching the delta reminds us that our analysis provides only a partial perspective and situated knowledge, mediated by the research tools and devices employed such as maps, historical documents, and so on (Haraway, 1988). In *Delta Methods*, Krause (2018) argues that researchers can use various research tools to zoom out from their field sites to see broader contexts and think about hydrosocial life-worlds at multiple scales. This research adopts a multi-sited ethnography to stitch together various situated perspectives in order to depict the broader deltaic environment.

Delta methods are also used to investigate how stakeholders' physical and social positionality shape hydrosocial lives in different parts of the Vietnamese Mekong Delta. This research teases apart the set of elements that constitute shrimp economies such as the materiality of the delta, the distinct characteristics of shrimp species, class relations and gender divisions (cf. Li, 2014: 16). In my field work, I followed a range of stakeholders engaged in four kinds of shrimp farming. First, I interviewed farmers doing integrated mangrove-shrimp farming with Forest Management Boards (FMBs), a local governmental sector, and NGO A, an international NGO based in Cà Mau.[5] Second, I interviewed officials and personnel at governmental and university research institutes working to promote alternating hybrid rice-shrimp farming in Bạc Liêu. Third, I studied intensive shrimp farming in a Khmer minority community in Bạc Liêu. (My interviewees included Phương, a Khmer Vietnamese woman who had emigrated to Taiwan for marriage to a Taiwanese farmer ten years earlier. Phương's family in Vietnam are engaged in commercial shrimp farming in Bac Liêu, in the Vietnamese Mekong Delta. She came from an ethnic minority [*dân tộc*] village where 73 percent of the population is Khmer, with the remainder made up of Kinh [the dominant Vietnamese ethnic group] and Chinese.) Fourth, I interviewed a Taiwanese businessman and some wealthy local farmers engaged in super-intensive shrimp farming.

The physical and social positionality of these groups and actors shape their valuations of water and decision-making in regards to water management and shrimp-farming practices (Ioris, 2012). The choice of monoculture or polyculture shrimp farming is influenced by the changing hydrological and ecological conditions in different parts of the Vietnamese Mekong Delta. As for social relations, farmers and companies conduct four kinds of shrimp farming with uneven investment capacities and under different local policies.

The temporality of the delta affects hydrosocial lives and research methods. I synchronised my research schedule to the natural rhythms of mangrove forest shrimp farming. Farmers harvest shrimp during the low tide at midnight on the 15th or 30th day of each month from the third to the eighth lunar months, which meant that I had to arrange my schedule to fit with the lunar calendar, each farmer's schedule, and government bureaucracy. As a foreign researcher, I had to apply for research permits three weeks in advance of my field work, and overnight access to mangrove forests in restricted areas required special research permission from the local government (cf. Turner, 2014). These rhythms – social, political, biophysical, and even planetary (i.e. lunar cycles) – make delta methods uniquely suited to understanding the dynamic delta environment.

SHRIMP PONDS: THE BASIC UNIT FOR SHRIMP FARMING

The shrimp pond is the basic spatial unit used for shrimp cultivation. When breeding shrimp, farmers, workers, and entrepreneurs use both river flows and various types of infrastructure to manage the quality and ecology of the soil and water in ways that help to prevent and control outbreaks of shrimp diseases. Despite the care farmers take in installing and maintaining their shrimp ponds, such ponds are still embedded in the delta and are subject to its rhythms. It requires meticulous work to balance and account for the dynamic tensions between the delta as a turbulent environment and an infrastructuralised object (Scaramelli, 2019).

While there are many types of shrimp farming with different shrimp pond arrangements, most Mekong Delta shrimp ponds share certain characteristics. Shrimp ponds are generally constructed to align with the wetness of the delta in two aspects: (1) land and soil quality, and (2) water quality and ecology. The land is the container for water and shrimp, and the soil determines the quality of that container (Krzywoszynska, 2019). Farmers usually let the soil rest before the start of the breeding season. They discharge water from their ponds, remove sludge from the previous season, and expose the soil to sunlight for a week to eliminate pathogens. They also use lime to ameliorate salinity and raise the pH

[5] To protect the confidentiality of research participants, the NGO featured in this study has been anonymised.

value of the soil. The sludge usually contains shrimp shells, excrement, and feed residue, which can raise the soil's levels of ammonia nitrogen, nitrous acid, and sulphides. The pH value of the soil will influence the pH value of the water and water ecologies in turn, thereby affecting the health of the shrimp. Thus, land and soil preparation requires letting the soil rest to reduce the risk of shrimp disease outbreaks.

At the same time, farmers seek to optimise water quality and ecology before and during the shrimp breeding season. Farmers usually pump water into their ponds from rivers and canals during the high tide, which brings clear seawater into the delta and ensures the shrimp ponds are less polluted by upstream agriculture. Farmers can directly evaluate water quality by its colour, or they can use a water quality monitoring app. such as Tôm Rùng, created by NGO A in Cà Mau. (High-quality freshwater in the delta resembles seawater in colour, since it contains good algae and less river sediment.) Farmers sterilise the impounded water for 10-20 days by adding chlorine, then they introduce tea seeds to kill fish and other potential shrimp predators (Figure 1). Finally, farmers spray probiotics (the benefits of which remain disputed) and minerals to increase the population of 'good germs' such as photosynthetic bacteria and aerobic bacteria.

Figure 1. Nam scatters tea seeds before releasing post-larval shrimp into the pond.

Source: Author

Even with careful management, however, the ponds are vulnerable to disease contagion from wastewater released by shrimp farms and other operations upstream, potentially causing substantial financial loss. Increasing shrimp density in the ponds also increases the production of shrimp shells, excrement, and ammonia, raising the risk of shrimp disease outbreaks. Furthermore, poor separation of water intakes and outflows allows wastewater to spill over to neighbouring shrimp ponds. Farmers and companies have uneven access to the land, capital, and technology required to effectively prevent disease, and this risk of financial loss reflects the dilemma of collective action for both family farms and corporations (Huang, 2015).

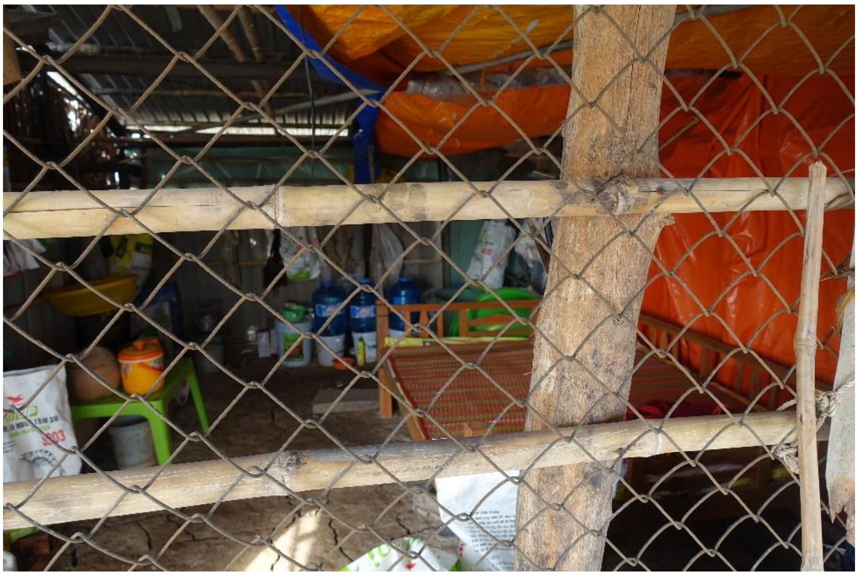
COMPARING HYDROSOCIAL LIVES FOR FOUR KINDS OF SHRIMP FARMING

Comparing hydrosocial lives for four kinds of shrimp farming in the Vietnamese Mekong Delta highlights the heterogeneous composition and multidirectional development of shrimp economies (cf. Pham et al., 2022).

Shrimp diseases and livelihood maintenance in intensive shrimp farming

Intensive shrimp farmers must be constantly at hand to feed and care for their shrimp, with their working time determined by production time. Depending on the current growth stage, farmers feed their shrimp commercial shrimp pellets in two or three evenly spaced daily feedings. During the first two months, farmers only need to visit their ponds at feeding time, leaving them free to engage in paid work elsewhere. For example, during this time, Hoàng (Thành's son in-law) works as a hired hand on other farms or nearby construction sites to earn more money, with his wife taking care of the noon shrimp feedings. However, as the shrimp grow to harvestable size, farmers usually stay in huts they build beside their ponds to guard their shrimp against poachers, sometimes using guard dogs as well (Figure 2). In Vietnam, labour for small-scale agriculture and aquaculture is mainly supplied through kinship (Belton et al., 2011; Porter, 2019), with daily life closely synchronised with the life cycle of the shrimp. Thu (Thành's daughter) and her husband Nam live very close to their relatives, so the extended family alternates on nighttime guard duty. While he is on duty, Nam only goes home for meals, spending the rest of the night beside the shrimp ponds.[6]

Figure 2. Thành's hut next to his shrimp ponds.



Source: Author

Intensive shrimp farming increases the risk of shrimp disease outbreaks and thus potential income loss. Farmers engaged in intensive breeding mitigate this risk and diversify their income through growing crops, day labour, and remittances from family members working overseas. Thành and his family employ four distinct strategies to secure their livelihood: First, if Thành finds dead shrimp in his pond, he

[6] Nam used to grow rice but changed to higher-margin shrimp breeding 20 years ago. Nam told me that the shift from rice to shrimp cultivation was not a difficult transition, and his knowledge of shrimp breeding is all self-taught. Nam can manage 10-12 shrimp ponds at a time, which is an impressive achievement. In contrast, Thành only manages 5-6 shrimp ponds at a time.

immediately sells his entire shrimp stock that same day. Buyers typically demand farmers provide laboratory tests to prove the health of their stocks (i.e. a negative test for antibiotics), a process that usually takes one day. However, farmers who are afraid of losing their stock to disease may skip the testing process and sell at a lower price. Second, Thành keeps two other pieces of farmland, on which he grows longan and pumpkins for extra income (Figure 3). Third, when the price of shrimp is low or if they lose their shrimp stocks to disease, Hoàng and Lộc will temporarily move to Hồ Chí Minh City to work in factories or forestry farms. Young farmers often shift between farming and day labour, implying that nonfarm work provides better income (cf. Nguyen et al., 2021). But despite his frustration at having to deal with the potential for shrimp disease, Hoàng still prefers living with his family and breeding shrimp to working in a factory in Hồ Chí Minh City. During the COVID-19 pandemic, they left Hồ Chí Minh City to return to Thành's home and reengage in shrimp farming. And fourth, Phương remits US$200 per month from Taiwan and occasionally sends additional funds to Thành to pay for the care of Phương's child in Thành's household and to shoulder some of the costs of shrimp farming inputs, particularly larvae from hatcheries.[7] This transnational remittance practice shows how small-scale and intimate forms of direct resource transfer support shrimp economies in the Vietnamese Mekong Delta (cf. Faier, 2013), and these four strategies collectively reflect ways that shrimp economies are associated with kinship and community ties.

Figure 3. Longan harvesting.

Source: Author

Industrial upgrading and capital accumulation in super-intensive shrimp farming

Super-intensive shrimp farming involves the use of shrimp ponds specially designed to control the deltaic environment to increase stock density while decreasing the risk of disease and accelerating the production cycle. These practices create a safer and more controllable container. First, the land is levelled

[7] Socio-demographic developments in Asian countries have increased education and employment opportunities for women, and socio-economically disadvantaged rural men in Taiwan and Korea have increasingly sought brides from developing countries (Bélanger and Wang, 2012). International marriages between Taiwan and Vietnam are largely facilitated by for-profit marriage agents (Wang and Chang, 2002). This practice creates a kind of 'transnationalism from below', coming from individuals in low social strata.

and cylindrical above-ground steel-walled ponds are built. The walls and base of the ponds are then lined with plastic sheeting (Figure 4) to isolate the water from the soil, thus allowing for better control over water quality. (The soil is seen as a potential pollutant – a source of bacteria, viruses, and chemical elements that could influence the water's pH value.) Water is then pumped from rivers and canals and sterilised by adding chlorine to water reservoirs, which are up to three times the volume of regular shrimp ponds. Operators instal pipelines from the water reservoirs to each shrimp pond, allowing the water to be changed daily. A discharge outlet at the centre of the pond is connected to a buried pipe, allowing for the discharge of wastewater as needed – for instance if excess ammonia builds up in the pond. Protein skimmers are installed at each pond to remove uneaten shrimp feed, shrimp waste, and suspended particulates, thereby better maintaining water quality and reducing the risk of shrimp disease. Dissolved oxygen is injected into the pond from above by ventilators and from below by submerged pipes, allowing farmers to maintain densities of up to 260-300 shrimp per square meter. The surface ventilators direct the pond's water flow to aid in the removal of shrimp shells and waste. These ventilators are more effective in the cylinder-shaped ponds than in traditional rectangular ones, the four corners of which function as dead zones that accumulate waste.

Figure 4. Super-intensive shrimp ponds.

Source: Author

This model allows for year-round shrimp cultivation, but it requires improved biosecurity and increased investment that few farmers can afford (Boyd and Watts, 1997). Furthermore, some farmers who have sought to upgrade to super-intensive shrimp cultivation lack the experience or support to properly install the required equipment and infrastructure, thus wasting much of their investment. In response, multiple consulting companies have been established in both the delta region and Hồ Chí Minh City to help farmers optimise the design of their super-intensive shrimp ponds.

The super-intensive model was developed to scale up shrimp output while minimising the risk of shrimp disease. In June 2020, Ming-Yi, the chairman of a Taiwanese shrimp breeding and processing company, constructed 40 super-intensive shrimp ponds to hold 100 million postlarvae for an estimated September 2020 harvest of 200 tons of whiteleg shrimp (*Penaeus vannamei*). Whiteleg shrimp are particularly vulnerable to disease during two distinct periods: the first 20 days and after 60 days. Longer breeding times expose these shrimps to higher contagion risks, so Ming-Yi's operation keeps breeding times to within 60 days, after which the shrimp are harvested and processed. This strategy has helped Ming-Yi outperform the competition in the small shrimp market niche and has accelerated the company's cash flow.

In super-intensive shrimp farming, foreign companies, urban entrepreneurial investors, and local farmers recruit workers to feed and care for shrimp and shrimp ponds in a process that frees the pond owners from the production cycle but binds labour to the land. Ming-Yi has constructed a dormitory near his shrimp farm (a so-called 'live-in' system) to house migrant workers from other provinces, ensuring round-the-clock pond monitoring and management (Huang, 2015). Like colonial plantations (Li, 2014), the live-in system in super-intensive shrimp farming leaves migrant workers highly dependent on aquaculture and vulnerable to exploitation. Each migrant worker is assigned to manage a certain number of shrimp ponds around the clock, including all feedings.

Despite the risks inherent in shrimp farming, the industry continues to draw foreign companies and urban entrepreneurs, while local farmers are increasingly investing to upgrade their ponds to super-intensive shrimp farming to boost productivity and reduce the risk of shrimp disease. Hải is a farmer who has been breeding shrimp for 20 years and is a long-time customer of the Charoen Pokphand Group (CP),[8] a large Thai-based agribusiness shrimp feed company. To minimise its risk exposure, CP does not engage in shrimp cultivation itself but rather sells shrimp feed, a product that farmers must purchase continuously throughout the production cycle (Goss et al., 2001). Encouraging farmers to upgrade to super-intensive shrimp farming helps CP drive increased shrimp feed sales. In 2017, CP brought Hải to tour super-intensive shrimp ponds and encouraged him to adopt this model. As a result, he changed from in-ground ponds to plastic-lined, above-ground ponds with automatic feeding machines and water pipelines. Hải thus benefits from reduced risk of disease outbreaks, while the payment owed to CP for the shrimp feed used is only due after the harvest.

Super-intensive shrimp ponds discharge large volumes of wastewater into the same canal systems from which downstream shrimp farms source their water, resulting in the spread of shrimp diseases. In response to this, the Ministry of Natural Resources and Environment now requires super-intensive shrimp farms to treat their wastewater before discharging it into rivers. One farm I visited had positioned an underground biogas tank at the pond discharge point to decompose organic waste over a period of weeks to months. Beginning in 2018, the ministry's Cà Mau field office conducted a two-year project to compare different models of wastewater treatment, but the office lacks sufficient personnel to effectively audit wastewater treatment at most farms.

Rotational arrangement in alternating rice-shrimp farming

Alternating rice-shrimp farming in particular shows how the seasonal change of freshwater and saline water in the Vietnamese Mekong Delta shapes farming practices and creates a distinctive water ecology (crops, shrimp, and bacteria) (Figure 5). The variation of water salinity is meticulously managed throughout the seasonal changes through the use of hydraulic infrastructure. During the dry season, canal managers open sluice gates to let saline water flow into canals. Farmers pump this saline water (around 5-25 grams of salt per litre of water) into their farmland to breed black tiger shrimp (*Penaeus monodon*). During the first 30 days of breeding, farmers usually fence the fry in a small zone with nets to protect them from being eaten by fish.

[8] CP was founded in 1921 in Thailand and emerged as one of the leading integrated food conglomerates in East and South Asia, expanding shrimp production outside Thailand to lower-cost areas (Goss et al., 2000). In 1988, CP established a representative office in Hồ Chí Minh City, followed in 1993 by the establishment of the CP Vietnam Cooperation (CPV), currently one of the leading foreign firms in Vietnam's shrimp aquaculture industry. It provides shrimp feed and larvae and is a strong backer of the super-intensive shrimp farm model. For instance, CPV promotes the three-stage CPF-combine shrimp farming technology to provide farmers with essential solutions (Son and Nguyen, 2022).

Figure 5. Preparing land for rice cultivation in July 2020.

Source: Author

During the rainy season, farmers grow rice and breed giant freshwater shrimp (*Macrobrachium rosenbergii*), both of which require lower water salinity. Thus, the soil is not only a container for water and shrimp but also a medium for growing rice. Farmers cultivate the soil following the shrimp harvest, depending on the seasonal rains to permeate the soil with lime and freshwater, thereby flushing out the salt (*rửa mặn*) over a period lasting around 30 days, depending on the volume of rainfall. Farmers discharge water from their ponds and paddies three times to complete the practice of desalinisation. Meanwhile, canal managers close sluice gates to isolate the freshwater from saline water intrusion. Canals thus become small-scale rain-fed freshwater reservoirs, isolated from the salinised coastal rivers, which are also polluted by upstream runoff. However, the stability and reliability of seasonal rainfall in the Mekong Delta is subject to significant disruption; monsoons may arrive late, and climate change and El Niño also affect the weather patterns (Mekong River Comission, 2022: 31). In response, the Vietnamese government has built the Cái Lớn-Cái Bé hydraulic system (*hệ thống thủy lợi Cái Lớn – Cái Bé*) in Kiên Giang, which protects inland fields from saline water intrusion and transports freshwater to Cà Mau to relieve water scarcity (Chanh, 2024).

This saline-freshwater interface creates two sets of multispecies relationships: saline water-shrimp-farmers in the dry season and freshwater-rice-shrimp-farmers in the rainy season (cf. Morita, 2017b). Seasonal changes in water quality and ecology are critical factors in reshaping multispecies relationships and decreasing the risk of shrimp disease. During the rainy season, farmers grow certain varieties of salt-tolerant rice (capable of tolerating water salinity of up to 5 grams of salt per litre of water) such as Cà Mau 1, Một bụi đỏ lùn, and other varieties of fragrant rice in the interface of fresh- and saline water. Farmers will space their rice seedlings widely enough to allow for giant freshwater shrimp breeding in the same paddies, reducing rice crop yields but also the risk of rice diseases. The shrimp farming sludge produced during the dry season is used as a natural fertiliser for the rice, and this practice of rice-shrimp rotation also reduces the risk of shrimp disease outbreaks by using freshwater to suppress the population of *Vibrios* bacteria during the rainy season. (*Vibrios* presents in marine environments such as brackish ponds and coastal areas and is the main pathogenic cause of shrimp disease.) The seasonal alternation of fresh/saline water and rice/shrimp cultivation allows the land to rest and creates a more biosecure environment for both rice and shrimp. Finally, rice-shrimp farming helps establish a natural food chain that does not rely on commercial shrimp feed, thus reducing production costs to farmers.

Farmers use this ecosystem to breed shrimp organically (*thiên nhiên*) and ecologically. Farmers engaged in alternating rice-shrimp farming are supported by government policy (policy number: 09/2000/NQ-CP *ngày* 15/6/2000) and several international NGO-supported cooperation projects to introduce improved farming techniques (Vandergeest et al., 2015). Farmers learn to cultivate rice and shrimp rotationally in rainy and dry seasons. In 2010, the Nam Sông Hậu Research Institute of Aquaculture published a manual to teach alternating rice-shrimp farming practices.[9]

Government agencies and NGOs also support and promote the formation of cooperatives (*hợp tác xã*) to provide financial and technical assistance, as well as to maximise farmers' bargaining power in the market. In 2019, the GEF Small Grants Programme released a report titled *Promoting Sustainable Value Chains in Rice-Shrimp*, aiming to strengthen rice-shrimp value chains by organising farmers into cooperatives to facilitate their market participation (Hội Thủy sản tỉnh Bạc Liêu, 2019).[10] However, based on their fieldwork on improved extensive shrimp farming in Cà Mau between 2008 and 2010, Ha et al. (2013b) observed that cooperative production clusters (*tổ hợp tác*) had failed to deliver market benefits to smallholders, fostering dependence on external assistance rather than strong partnerships between farmers and the private sector. Thus, alternating rice-shrimp farming carries a lower risk of disease, but farmers in this model still have limited bargaining power over prices.

Forest conservation and organic shrimp in integrated mangrove-shrimp farming

Land-use and afforestation policies have been developed to promote integrated mangrove-shrimp farming in Cà Mau as an environmentally friendly model (Ha and Bush, 2010) (Figure 6). Whereas mangrove swamps had previously been exploited for lumber, following the end of the Vietnam War, the Forest Management Board (FMB) in Cà Mau promoted mangrove conservation and restoration to prevent coastal erosion and promote aquaculture expansion. Mangrove reforestation also emerged as a climate change adaptation and for the restoration of ecosystem services. According to policy 135/2005/NĐ-CP, FMBs may contract out national forest lands to residents for tree planting and aquaculture (*giao nhận khoán rừng và đất rừng sản xuất*). The government's afforestation policy extends state control over the land and its people (McElwee, 2016: 169). Contracting forest land out to individual peasant households helps the government maintain coastal environments and prevents destructive development (Vandergeest et al., 1999).

The regulation of mangrove forests and shrimp ponds establishes a land-mangrove-shrimp relationship. The land is compartmentalised into mangrove forests and shrimp ponds. The afforestation policy and the forest leasing contracts set the number of reforestation areas, regulate the forestry and shrimp pond areas, and reform the human-mangrove-shrimp relationship. The contracts require FMBs to train farmers in the cultivation and care of mangroves. Farmers receive planting fees in the first year only, and civil servants from the FMBs and forestry police officers (*kiểm lâm*) conduct regular inspections to ensure the forests are properly maintained. In the Cà Mau peninsula, the leasing contracts allow farmers to earn profits through logging and ecological shrimp farming. After receiving permission from their local FMB, farmers can harvest mangrove trees once every 12-15 years, with the logging profit shared between the farmer and the FMB. Contracted farmers are required to replant the harvested areas prior to the end of the contract period.

[9] Project participants include the Research Institute of Aquaculture Nam Sông Hậu Branch, Cần Thơ University, the Australian the Centre for International Agricultural Research, the University of New South Wales, Griffith University, and Charles Sturt University.

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

Figure 6. Integrated mangrove-shrimp farming.

Source: Author

In integrated mangrove-shrimp farming, farmers do not feed shrimp using commercial shrimp feed but rather rely on algae, plankton, and other natural food sources from river water. Compared with intensive and super-intensive shrimp farmers, farmers practising integrated mangrove-shrimp farming have more free time and are less beholden to commercial feed suppliers. Thus, many farmers can maintain their rural shrimp ponds while also working in downtown Cà Mau City or local towns. For instance, Trúc, a mangrove-shrimp farmer, works as a financial consultant in a life insurance company and rents a room in downtown Cà Mau. In another example, Dũng works for NGO A but shares his mangrove-shrimp ponds with his brothers in Cà Mau. In addition, ecological shrimp breeding reduces the risk of disease outbreaks due to the low shrimp density of 1-6 black tiger shrimp per square meter.

In the mangrove forests, black tiger shrimp are harvested in time with biophysical and planetary rhythms (see also Simon, 2021). Farmers harvest shrimp during the low tide at midnight on the 15th or 30th days of the lunar month, which provide the highest tidal range, with the canal level at its lowest point below the sluice gates of the shrimp ponds. This gives farmers more time to release water, collecting shrimp as the water flows through the sluice. Farmers harvest shrimp several times from the third to the eighth lunar months, after which time the ponds are nearly depleted.

During the Mid-Autumn Festival (the fifteenth day of the eighth lunar month), I visited Nghĩa, a mangrove-shrimp farmer and vice-principal at a high school in Cà Mau. Before harvesting his shrimp, Nghĩa placed a moon cake and incense upon the sluice gate to pray for good luck. Wearing a head-mounted flashlight, Nghĩa pulled up a net and poured its contents into a large bucket, which he then carried back to his house. Sifting through the pile of leaves and branches, Nghĩa and his family picked out various types of shrimp, crab, and fish, keeping the large black tiger shrimp (weighing an average of 50 grams each) and returning the rest to the pond. While Nghĩa engages in polyculture shrimp farming, only black tiger shrimp larvae are deliberately seeded in the ponds, with the rest of the species brought into the ponds with the inundation of saline water. The collected shrimp were immersed in ice water to keep them fresh overnight until the traders arrived the next day. These traders are keenly attuned to the rhythms of the spring tides (fortnightly high tides), arriving without being summoned when harvesting takes place. Transport by road is difficult in this area, and the traders arrive by boat via the canals.

DISCUSSION

Drawing on the theoretical lens of hydrosocial life, this research shows how shrimp growers manage water quality, quantity, and ecology to create the ecological conditions of production within the deltaic landscape. These systems exemplify how water-shrimp-human-delta relations are co-constituted and must be aligned to sustain livelihoods, accumulate capital, and prevent disease. In each system, these relational elements are materialised as specific objects (e.g. saline, fresh-, or wastewater; whiteleg, black tiger, or giant freshwater shrimp) and subjects (e.g. local farmers, urban entrepreneurs, or foreign companies), shaped by their spatial positions in the delta and by prevailing socio-economic conditions (see Table 1). These systems also produce uneven economic, social, and environmental outcomes, as husbandry practices and pond design are shaped by differential access to capital and labour, land regulations, and infrastructural investments. These systems are characterised by dynamic transitions and tensions, as farmers adjust their practices in response to household income needs, biosecurity concerns, and policy measures.

The expansion of intensive and super-intensive shrimp farming was initially driven by households' aspirations for higher income and subsequently by growing concerns over biosecurity and advances in aquaculture technologies. In the 1990s, intensive shrimp farming spread both along the coast – where it contributes to mangrove degradation – and inland, where it promotes the salinisation of freshwater zones and puts increasing pressure on freshwater agriculture. However, from 2000 to 2020, the total area of shrimp aquaculture in coastal provinces remained relatively stable, increasing moderately from 619,000 to 856,000 ha, in contrast to the sharp expansion of rice cultivation during the same period (Vu et al., 2022). But even though the extent of shrimp farming has plateaued, transitions between different farming models continue to occur. It was not until around 2017 that many intensive farms began upgrading to super-intensive models, facilitated by technological developments aimed at boosting productivity and reducing investment risks. Upgrading to super-intensive farming requires 1-10 ha of land and approximately 400-500 million Vietnamese đồng (US$16,000-20,000) per hectare for infrastructure, plus an additional 400-500 million đồng (US$16,000-20,000) for shrimp feed, electricity, and other recurring expenses (Trường, 2024). These requirements are far beyond the means of nearly all small-scale producers and even most urban entrepreneurs. To promote this transition, some larger companies, such as Tập đoàn Thủy sản Việt Úc and Công ty Trúc Anh BiOtech, have built super-intensive farms as demonstration sites to attract local farmers to adopt similar models.

While farmers are incentivised to adopt shrimp monoculture in order to maximise household income, doing so increases the risk of shrimp infection and thus severe economic loss. In terms of productivity and net benefits, intensive and super-intensive shrimp farming are more profitable than the other two models (Table 2). For instance, super-intensive shrimp farming can produce 50-55 tons shrimp per hectare (Huỳnh, 2022). However, this higher productivity does not necessarily translate into higher profits because of fluctuations in the shrimp price. In 2024, a farmer reported that he operated two super-intensive shrimp ponds (around 6000 square meters) at a cost of 3.3 billion Vietnamese đồng (approximately US$132,000) but only earned 3.5 million đồng (approximately US$140), for a margin of about one-tenth of one percent (Lao Động, 2024). In addition, these models also carry a higher risk of disease outbreaks due to the inherent economic and ecological contradictions within shrimp monoculture (Bustos-Gallardo and Irarrazaval, 2016). High stocking densities and large-scale operations create ideal conditions for pathogens to emerge and spread – what Hinchliffe et al. (2016: 13-14) describe as 'disease situations'. Even super-intensive shrimp farming, which uses more biosecure designs and practices, still faces a 10-20 percent risk of infection. This persistent vulnerability stems from the fact that these ponds are embedded in, and cannot be fully isolated from, the broader deltaic environment. By contrast, integrated mangrove-shrimp systems and alternating rice-shrimp farming generate lower yields and smaller net benefits compared to super-intensive systems but carry significantly lower risks of disease outbreaks. In rice-shrimp farming, farmers typically breed 2-10 black tiger shrimp per square metre within a natural food chain, resulting in lower yields – around 4-4.5 tonnes per hectare in 2022 in

Bạc Liêu province (Hiệp Hội Lương Thực Việt Nam, 2022). However, black tiger shrimp raised in integrated mangrove-shrimp systems are exported to high-value markets in the United States and Europe, making them comparatively more profitable despite their lower output.

Shrimp polyculture models are more consistent with the goals of the Vietnamese government and international organisations to protect coastal ecosystems and promote environmental sustainability. The *Mekong Delta Plan* encourages farmers to shift from monoculture to polyculture aquaculture systems, as the latter can improve brackish water quality and reduce the risk of disease outbreaks (Netherlands Delta Commission, 2013: 18, 95). Among the polyculture models, mangrove-shrimp farming is particularly favoured for its ecological benefits: Mangroves help trap sediment, stabilise shorelines, and enhance coastal resilience (Netherlands Delta Commission, 2013: 95). From 2011 to 2021, various mangrove afforestation and rehabilitation initiatives were implemented in Cà Mau, Bạc Liêu, Sóc Trăng, and Kiên Giang by international NGOs such as Wetlands International, the Dutch engineering firm Royal HaskoningDHV, the German development agency GIZ, and the Integrated Coastal Management Programme. These efforts focused primarily on restoring mangroves in abandoned shrimp ponds to enhance coastal protection (Clough et al., 2016; Erftemeijer et al., 2021). Research indicates that restoration is more viable in former mangrove areas. Establishing new mangrove forests often requires substantial engineering interventions to create appropriate growing conditions – an approach that is both labour- and cost-intensive. This does make it difficult to replace shrimp monoculture in inland areas (Erftemeijer et al., 2021: 123).[11]

Vietnamese shrimp farmers have experienced deagrarianisation without depeasantisation, meaning that the peasantry continues to engage in both subsistence and commercial activities, maintaining elements of both rural and urban lifestyles (Nguyen et al., 2020b, 2021). This research shows that many shrimp farmers continue to work their land while also taking up non-farm employment to diversify their income; some even hire labourers to manage shrimp cultivation, making it difficult to clearly define their class position. Unlike previous studies in the Red River Delta, which have tended to focus on rural-to-urban migration (Nguyen, 2016), this research highlights how farmers organise both farm and non-farm work in relation to the growth cycles of shrimp and the monthly and seasonal rhythms of the delta.

Taken together, these findings highlight how hydrosocial lives across the four shrimp farming systems are reshaped – through transitions between farming models, enabled by shrimp growers' adaptive practices and institutional interventions by governments and NGOs – revealing the spatial and temporal dimensions of shrimp farming in the Mekong Delta. Spatially, the expansion of shrimp monoculture and the promotion of polyculture reflect ongoing contestations over land use in the delta. Nevertheless, the four farming models are not isolated units; they are ecologically interdependent, as all four discharge wastewater into shared waterways, generating environmental externalities that degrade water quality and facilitate the spread of disease across the delta. Temporally, farmers and workers organise their activities in accordance with shrimp breeding and harvesting periods, as well as the delta's rhythms and volatilities. These temporalities are further shaped by the demands of non-farm employment and shifting policy agendas.

[11] In addition, in order to be effectively implemented by Vietnamese technocrats, the Mekong Delta Plan, a vision introduced by Dutch experts, needs to be aligned with existing Vietnamese programmes and resolutions – such as the New Rural Development (*Xây dựng nông thôn mới*) and the New-style Cooperatives (*Hợp tác xã kiểu mới*) programmes (Weger, 2019: 187).

Table 1. Comparison of hydro-social lives in four types of shrimp farming (Source: Author)

Farming type	Ecological conditions of production	Agrarian, technical, and environmental changes
Intensive shrimp farming	*Natural rhythms and volatilities* • Pumping saline water during high tide • Prone to shrimp disease outbreaks *Infrastructural modification* • Increasing shrimp density by using ventilators to provide more dissolved oxygen	• Shrimp farming is a double-edged sword for poverty alleviation • Shrimp economies are supported by kinship, community ties, and international remittances to mitigate the impact of shrimp diseases • Using shrimp feed shapes the everyday life of farmers
Super-intensive shrimp farming	*Natural rhythms and volatilities* • Pumping saline water during high tide *Infrastructural modification* • Increasing shrimp density by using ventilators and pipelines to provide more dissolved oxygen • Improving biosecurity by installing plastic pond linings to isolate ponds from the surrounding soil and flushing ponds daily to overcome natural obstacles in the delta	• Some local farmers upgrade their ponds to super-intensive shrimp farms; foreign companies and urban entrepreneurs invest using this model to accumulate capital • Hiring workers and operating the living system to look after shrimp 24/7 • Increasing productivity, accelerating shrimp growth, and reducing the breeding period
Alternating rice-shrimp farming	*Natural rhythms and volatilities* • Breeding black tiger shrimp in the dry season and growing rice and giant freshwater shrimp in the rainy season using natural food chains • The seasonal change of fresh and saline water reduces the risk of shrimp disease *Infrastructural modification* • Controlling seasonal changes of water quantity and quality using canals, sluice gates, and regional hydraulic infrastructure	• Organising rice-shrimp production through cooperatives • Rice-shrimp farming training and guidance • Alternating rice-shrimp farming as a climate change adaptation
Integrated mangrove-shrimp farming	*Natural rhythms and volatilities* • Breeding organic black tiger shrimp along with other shrimp species, fish, and crab using the natural food chains in the mangrove forest ecosystem • Regular water replacement, harvesting shrimp in time with the delta's tidal rhythms *Infrastructural modification* • Collecting shrimp from water flowing through the sluice gates	• Afforestation policy allows Forestry Management Boards to contract farmers to protect and expand mangrove forests • International NGOs provide training and resources for organic shrimp farming • Farmers engage in other paid labour in the cities when not tending to their shrimp

Table 2. Production and net benefits from four types of shrimp farming.

Farming type	Average production (ton/ha/crop)	Estimated average net benefit (VND/ha/crop)	Risk of shrimp diseases
Intensive shrimp farming	0.5246 ± 0.1401 (Cà Mau)	551 ± 342 million (Cà Mau)	High
Super-intensive shrimp farming	40-50 (Bạc Liêu)	1 billion VND per hectare for three shrimp crops a year (Bạc Liêu)	Medium
Alternating rice-shrimp farming	0.2293 (Cà Mau)	33.4 million (Cà Mau)	Low
Integrated mangrove-shrimp farming	0.2678 (Cà Mau)	60.1 million (Cà Mau)	Low

Source: Compiled by Author

CONCLUSION

This paper demonstrates how the notion of hydrosocial life can expand water research by considering both social forms of life and multiple life forms in bioeconomies. It foregrounds relations of water, life, and economies in shrimp aquaculture from two aspects: (1) ecological conditions of shrimp production, and (2) agrarian, technical, and environmental changes in the deltaic environment. This paper argues that shrimp farming organises hydrosocial lives to construct ecological conditions of production, particularly the spatiality and temporality of the delta, for capital accumulation and disease prevention. At the same time, hydrosocial lives in four kinds of shrimp farming are unevenly shaped by agrarian transformations, technical development, and environmental changes.

In hydrosocial lives, ecological conditions of shrimp production are underpinned but also impeded by the delta as a turbulent environment and an infrastructuralised object. The relations among ecology, environment, and infrastructure are contested and inseparable (Hetherington 2019; Scaramelli 2021: 85). These dynamic relationships are reflected in the fashioning of shrimp ponds, husbandry practices, and the management of shrimp disease. On the one hand, the delta is a turbulent environment in which the temporalities of commercial shrimp farming, such as the growth rate of shrimp and the circulation of capital, are related to the temporalities of nature, such as the daily and monthly rhythms of tides, seasonal changes, and the variation of wetness and salinity. On the other hand, the dynamism of the delta can be effectively stabilised through the introduction of devices and infrastructure to manage the spatio-temporal distribution of freshwater, saline water, and wastewater. The infrastructuralised delta assists shrimp growers in overcoming natural barriers and reducing the risk of shrimp disease to accelerate the life cycle of shrimp and speed up the return on capital (cf. Banoub et al., 2021).

Shrimp economies are articulated with multiple spatialities and temporalities across different physical locations and social relations, specific to four types of shrimp farming. The differences between these four farming methods produce an uneven impact of agrarian, technical, and environmental changes on the everyday lives of shrimp growers. Shrimp cultivation requires aligning the lives of farmers and workers with the life cycle of the shrimp (cf. Ha et al., 2013a; Blanchette, 2020). However, depending on their means of production and capitalist relations, farmers adopt different practices to breed shrimp, maintain water ecologies, and prevent shrimp diseases (also see Lien, 2015: 126). Some farmers, particularly those engaged in intensive shrimp farming, are more vulnerable to outbreaks of shrimp diseases and seek to mitigate this risk by mobilising kinship and community resources to diversify their income sources. Others adopt the polyculture model to lower the risk of shrimp diseases, but this leaves them more reliant on the natural rhythms of the delta (Simon, 2021).

This paper also contributes to delta studies by demonstrating the versatility of delta methods. The spatial and temporal dynamics of the delta not only constitute shrimp economies and hydrosocial lives but also shape data collection and research design (Krause, 2018). As Cons (2025: 13) argues, "deltas, then, are many things. Amphibious, fragmentary, and contested, they refuse to cohere as singular things". This research shows that a multi-sited ethnography can capture the delta's multifaceted nature by tracing its volatility and the rhythms of days, months, and seasons, and by moving across different parts of the Mekong Delta. Crucially, delta methods do not merely assemble perspectives from different places; they also make visible the internal dynamics, tensions, and asymmetries within the delta itself. Therefore, delta methods can be a useful approach for geographers to unpack dynamic relations between land and water in other landforms.

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