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RESEARCH

Salinizing livelihoods: the political ecology of brackish water shrimp aquaculture in South India

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Abstract

The growth of brackish water aquaculture globally and in India is driven by a discourse that naturalizes salinity and sees aquaculture as an alternate livelihood and a good source of food and nutrition in coastal areas. In this paper, we take issue with such a discourse and argue in particular that brackish water *shrimp* aquaculture is as much a cause of increased salinity as it is a response to it. We also highlight, through a case study of two villages in south India, that aquaculture farmers are relatively influential in political and economic capital and are mostly not small farmers. The paper further claims the growth of shrimp farms in the region has resulted in a declining area under productivity of paddy cultivation and pollution of fishing grounds and drinking water as well. Our findings suggest the need for policy makers to take a more critical look at brackish water aquaculture and the possible irreversible costs that they might have on coastal lands and rural livelihoods.

Keywords Salinity · Brackish water aquaculture · Political ecology · Livelihood

Introduction

Despite its recent chequered past (Jayanthi et al. 2018; Ohja and Chakrabarty 2018; Morshed et al. 2020; Ahmed and Thompson 2019; Salunke et al. 2020; Loc et al. 2021), brackish water shrimp aquaculture continues to be promoted globally and in south and southeast Asia in particular.[1] International organizations, such as the FAO (2020), see in aquaculture more generally an excellent opportunity for improving rural livelihoods, food supply and nutrition, especially for small farmers. Equally important, brackish water shrimp aquaculture, despite its well-documented environmental problems, is justified discursively by invoking salinity as "natural" in coastal areas and arguing that increased salinity over time is making land unsuitable for agriculture.

The main focus of this paper is to critique this discourse of salinity and analyze the material consequences of brackish water shrimp aquaculture. This requires understanding the naturalness of salinity in coastal areas, the complex brackish-freshwater dynamics of the coast and how both natural and human factors have changed these dynamics. By taking a political ecology approach to understanding the growth of brackish water shrimp aquaculture, our starting point is that the environment is socially constructed and politicized. This implies two things: (1) that the promotion of brackish water shrimp aquaculture is a political choice amongst multiple choices and (2) that brackish water shrimp aquaculture has differential impacts across the socio-ecological landscape. Hence, while brackish water shrimp aquaculture might be a "natural"[2] choice in coastal areas, its appearance in the landscape is the product of particular policy and place histories.

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[1] We use the terms aquaculture, brackish water aquaculture and brackish water shrimp aquaculture. Aquaculture includes fresh water aquaculture, brackish water aquaculture and mariculture, and brackish water shrimp aquaculture is a subset of brackish water aquaculture.

[2] Our use of the word "natural" here is to highlight policy makers' assumption that since coastal areas are saline, it is only logical (or natural) to promote brackish water aquaculture.

We trace these particular policy and place histories in the Indian context by looking at the role of the state in promoting brackish water shrimp aquaculture in two villages in Cuddalore district, Tamil Nadu - Thandavarayancholagan-pettai (T.S. Pettai) and Pichavaram, the former a fisher village and the later an agrarian village. We add to the literature that has focused on the role of state institutions in promoting aquaculture under conditions of salinity, by focusing more on the "local" state, namely how have state interventions at the local-level increased salinity and how have state agencies, if at all, promoted aquaculture. Our intent in doing so is to speak directly to policy and scholarly claims that brackish water shrimp aquaculture provides livelihood benefits to small farmers. We not only suggest this is not the case in our study area where farmers with more economic capital, political connections, and locational advantages take up shrimp aquaculture, but also that aquaculture has adverse impacts such as loss of land for agriculture, declining fish availability, reduced employment and poor quality drinking water amongst other things. We focus on differential impacts of aquaculture across caste and location within the two study villages. Finally, we pay attention to the many "illegalities" in the spread of brackish water shrimp aquaculture in the region, both in terms of violations of rules governing brackish water aquaculture set by the Coastal Aquaculture Authority (CAA) and in relation to regulating activities in the coastal zone.[3] By coining the term salinized livelihoods, we try to capture both the increasing spread of brackish water shrimp aquaculture and the livelihood challenges people face because of its spread.

The rest of the paper is divided as follows. In the next section, we summarize the political ecology literature on brackish water shrimp aquaculture and identify the research gap. This is followed by a brief methodology section. Our findings are divided into four sections. We have one section on the discourse and growth of brackish water aquaculture in India and our case study region and another in which we look at who the beneficiaries are of brackish water aquaculture in our two case study villages. The other two sections look at the adverse socio-ecological impacts of brackish water shrimp aquaculture and violations of coastal zone regulations in these villages. This is followed by a discussion section that elucidates on our main findings. Our conclusion summarizes and raises doubts about the future of brackish water aquaculture.

[3] In India, development activities in the coastal zone are regulated by the Coastal Zone Regulation (CRZ) notification which has been amended and redrawn on a number of occasions since its first enactment in 1991. The original notification emphasized the precautionary principle with regard to allowing industrial activities in the coastal zone (upto 500 ms from the High Tide Line (HTL).

The political ecology of brackish water shrimp aquaculture

There is a significant literature that explicitly or implicitly uses a political ecology lens to examine brackish water shrimp aquaculture. Political ecology, as a perspective, is interested in analyzing how politics and power shape the allocation of resources and who the winners and losers are. Attention has been given to the hegemonic role of international organizations, the state and private capital in furthering brackish water shrimp aquaculture. Nash (2011) traces the global history of aquaculture by examining how international organizations such as the Food and Agricultural Organization (FAO) of the United Nations started promoting aquaculture aggressively, along with capture fisheries, in the early 1950s, as a result of food shortages in the post-World War II period, and in pursuance of its stated aim of defeating hunger and promoting food security and nutrition (Nash 2011). Immanuel (2019) and Immanuel and Narayanan (2022, 2022a), in a similar vein, highlight the role of the United Nations Development Programme (UNDP) and FAO in the 1980s in promoting aquaculture and more recently Blue Economy policies.

Other studies focus more on the role of nation-states in the promotion of brackish water shrimp aquaculture. There are country studies for Thailand (Vandergeest et al. 1999), Cyprus (Hadjimichael et al. 2014), Bangladesh (Paprocki and Cons 2014), and Indonesia (Armitage 2002) amongst others as well as comparative studies, for example, of multiple south-east Asian countries (Hall 2004), all of which illustrate the state's role in promoting aquaculture. India is no exception. Immanuel (2019, 2020) and Immanuel and Narayanan (2022, 2022a) detail the institutional history of fisheries and aquaculture in India from the 1950s and the adoption of a National Aquaculture Development Plan as part of an initiative by the UNDP and FAO to improve technical expertise in aquaculture, something that was later mandated for aquaculture. The establishment of the Central Institute for Brackish Water Aquaculture (CIBA) in 1987 as a nodal agency to promote research in brackish water aquaculture was the culmination of the state's efforts. The establishment of the Marine Products Export Development Authority (MPEDA) to promote exports played a critical role in targeting foreign markets. (Silas 2003; Salunke et al. 2020).

Political ecology studies also look at the role of capital in the proliferation of brackish water aquaculture and who the beneficiaries of aquaculture are. Many studies argue that the main beneficiaries of brackish water shrimp aquaculture are large corporations and richer farmers (Mukul 1994). Mukul (1994), in the context of southeast India, highlights that both foreign and Indian capital drove the growth of brackish water

shrimp aquaculture; Adduci (2009) makes a similar argument in her study of the Chilika Lake in Odisha, but also alludes to a burgeoning "rentier class." Studies on Bangladesh by Abdullah (2016), Adnan (2013), and Paprocki and Cons (2014) all argue that higher income households derive the greatest income from aquaculture though Adnan (2013) speaks of de facto access through clientelism by small farmers and Abdullah (2016) acknowledges that small farmers too take up aquaculture but benefit less due to smaller operational holdings. Vandergeest et al. (1999) argue, in the context of Thailand, that the role of corporations was limited in the early phases of brackish water aquaculture in the 1990s and that in some regions of the country smaller farmers did take up aquaculture significantly, making it hard to generalize as to whom the main beneficiaries are.

What is less in dispute are the adverse environmental impacts of brackish water shrimp aquaculture, including habitat (mangrove) destruction (Bhatta and Bhat 1998; Vandergeest et al. 1999.; Paez-Osuna 2001; Jayanthi et al. 2018), deteriorating water quality (Farmaki et al. 2014; Islam and Yasmin 2017; Salunke et al. 2020), biotic depletion (Paez-Osuna 2001), eutrophication (Paez-Osuna 2001), excess by-catch (Naylor et al. 2000)[4], and spread of disease (Islam and Yasmin 2017). These environmental impacts can have consequent socio-economic impacts as well, for example the loss of fisheries and agricultural lands (Jayanthi et al. 2018; Morshed et al. 2020) which could lead to people migrating in search of jobs. Brackish water shrimp aquaculture can also result in the privatization of public land if the state prioritizes aquaculture and closes its eyes to possible illegalities (Mukul 1994). These problems are not geography specific. While most of the evidence regarding the adverse environmental impacts of brackish water aquaculture come from southeast Asia and south Asia, not surprisingly given that is where it is most prominent, there are also studies from Australia (Doupe et al. 2003) and the United States (Pine and Boyd 2011) that highlight similar environmental problems.

With regard to salinity, the focus of our paper, a number of studies illustrate that brackish water shrimp aquaculture while suitable to saline (coastal) landscapes also increases the level of salinity. Morshed et al. (2020) and Rahman et al. (2019) highlight how brackish water shrimp aquaculture has resulted in high salinity levels in agricultural lands and delta regions in Bangladesh. Other studies that touch upon the salinity issue include Vandergeest et al. (1999) for Thailand, Loc et al. (2021) for the Mekong Delta in Vietnam, Pine and Boyd (2011) for the southern United States and Doupe et al. (2003) for Western Australia. Ohja and Chakrabarty (2018) and Jayanthi et al. (2018), both using satellite data, illustrate the increasing salinization of coastal lands on the east coast of India. Other studies such as Gopinath et al. (2019) attribute increased salinization more generally to greater groundwater extraction while Rahman (2019) on coastal Bangladesh focuses on changing climatic conditions as a driver of increased salinity.

In this paper, as pointed out at the outset, we problematize salinity in more detail to get a better understanding of the political ecology of brackish water shrimp aquaculture and its spread in our two case study villages. As Pompoes (2022) argues, salinity in the literature has been largely seen in terms of its excesses and its adverse consequences. We focus more on how salinity as a discourse has increasingly been used as a justification for brackish water aquaculture at the policy level, how it is produced at the local level, and how brackish water shrimp aquaculture has salinized livelihoods in segmented ways, i.e., different groups of people are impacted differentially.

Methodology

As the paper focuses on the discourse and materiality of brackish water shrimp aquaculture, we employed multiple methods to address our objectives. First, we examined policy documents and pronouncements with regard to the promotion of aquaculture. How was brackish water aquaculture justified? How have discursive justifications changed, if at all, over time and how have they translated into the growth of brackish water shrimp aquaculture? Second, we undertook detailed fieldwork in two villages in the south of Cuddalore district. Here we focused again on what discourses actually drove the growth of aquaculture and what the material impacts of this growth were on different sections of society. We examined policy documents of the FAO and the website of WorldFish. We spoke to 10 aquaculture farm owners, but had to settle with the details provided by only eight shrimp farm owners as information was incomplete in the case of two owners. Our calculations suggested that there are approximately 27 owners in the two villages; hence we interviewed about 30% of the total owners. Quite a few owners we approached chose not to interact. Moreover, given the history of protest against aquaculture in this region, owners were even more cautious. Hence, ascertaining accurate data on land holdings was difficult. Moreover, we were unable to cross check what people told us about the extent of their total landholdings or the extent of land they had under aquaculture. The former would have required accessing the revenue records and cross-checking title deeds. The latter was a problem because CAA records only have the names of owners of farms that have licenses. Nonetheless, using the information provided, we broadly mapped out the economic, political and social status of these eight aquaculture farm owners. In addition, we spoke to 43 individuals from different caste

[4] The search for wild seed or brood stock can result in by-catch.

groups and locations of the villages so as to detail the socio-economical and geographical differences within brackish water shrimp aquaculture and its impacts.

In order to understand whether or not aquaculture farmers complied with regulations, we looked at official data from the Coastal Aquaculture Authority (CAA) with regard to licensed farms and ground-truthed these numbers. We also geo-referenced aquaculture farms using Google earth landsat images on to state-approved coastal zone management maps of the Tamil Nadu Coastal Zone Management Authority. This allowed us to see whether there were any violations of the coastal regulation zone (CRZ) notifications.

Discursive terrain and growth of brackish water aquaculture

As Nash (2011) illustrates in his global institutional history of aquaculture, international organizations such as the FAO started promoting aquaculture in the 1950s as part of a wider strategy to address food shortages and food security in the post-WWII period. The support for aquaculture, however, really picked up in the 1970s. Immanuel and Narayanan (2022a: 136) argue that aquaculture increasingly was seen as an important contributor to livelihoods and food security in a context of perceived dwindling fish stocks. Aquaculture, for food security, was they argue, the "saviour narrative" that drove the aquaculture agenda. Fast forward to the present and this discourse continues to drive the promotion of aquaculture, not only by organizations such as the FAO but also non-profit research institutions such as WorldFish. The saviour discourse is also central to the Blue Economy, Blue Growth and Sustainable Development Goals (SDGs) (Ibid). In India too, as in many other countries, these discourses have driven aquaculture.

But while livelihoods, food security and nutrition drive the discursive push for aquaculture, in the case of brackish water aquaculture, salinity has become increasingly central to this discourse. CIBA's Vision 2050 document identifies lands that have potential for brackish water aquaculture. These lands, according to CIBA, are "saline" lands that are no longer viable for agriculture. CIBA officials, in interviews conducted by the first author,[5] repeatedly spoke about how brackish water aquaculture was a solution to deteriorating livelihoods in coastal areas because of high levels of salinity. The same Vision 2050 document, mentioned above, argues that brackish water aquaculture has enormous potential to expand for two reasons. The first reason is the general feeling within government institutions that marine stocks are being overexploited and need to recover and hence brackish water aquaculture is likely to play an increasingly significant role in driving production (CIBA 2015). Second, in the states where brackish water aquaculture has potential, namely West Bengal, Gujarat, Andhra Pradesh, Maharashtra, Kerala and Tamil Nadu, only 14.75% of total utilizable land for brackish water aquaculture across these states has been put under aquaculture thus far (CIBA 2015: 15).

Without a doubt, the discursive push for aquaculture has translated into significant growth of the sector globally from the mid-1980s especially (FAO 2020). Whereas average annual global aquaculture production was 14.9 million tons per year between 1986 and 95, it increased to an average of 34.2 million tons annually between 1996 and 2005 and an average of 59.7 million tons annually between 2006 and 2015. By 2018, it had gone up to 82.1 million tons annually or approximately 46% of total fish production, far higher than the approximately 15% contribution in 1980 (Ibid: 2).

In India, total aquaculture production grew from approximately 0.63 million tons in 1985 to 7.8 million tons in 2019.[6] As total fish production in 2019–2020 was approximately 14.2 million tons, this suggests that aquaculture accounted for over 50% of total production. Inland freshwater aquaculture continues to account for the vast majority of aquaculture; in 2019–2020, it comprised 88% of total culture fisheries. Brackish water aquaculture, mostly shrimp, was almost non-existent in the mid-1980s, except for approximately 1000 tons of *Penaeus monodon* (Black Tiger Prawn). Large areas of coastal India were put under brackish water shrimp aquaculture in the 1980s and early 1990s. Much of this investment took place on the east coast of India, primarily Andhra Pradesh and Tamil Nadu, but other areas such as Chilika Lake in Odisha also witnessed brackish water shrimp aquaculture's spread (Adduci 2009; Nayak 2017). Despite significant local resistance (Mukul 1994; Goss 1998) and a Supreme Court judgment (S. Jagannath vs. Union of India & Ors) mandating the establishment of a Coastal Aquaculture Authority and the prohibition of any form of semi-intensive and intensive aquaculture in Coastal Regulation Zone (CRZ) areas, brackish water shrimp aquaculture grew. *Penaeus monodon* was the main species until 2009–2010 (Salim et al. 2019), but thereafter gave way to *Litopenaeus vannamei* (Pacific White Shrimp or King Prawn). In the year 2020–2021, India produced 815,745 MT of *Litopenaeus vannamei* of which 492,271 MT or close to 60% was exported to countries such as the USA (56.37%), China (15.13%), the European Union (7.83%) and southeast Asia (5.76%).[7]

[5] The first author met scientists at CIBA on February 23, 2021.

[6] https://www.fao.org/fishery/en/statistics.

[7] https://mpeda.gov.in/wp-content/uploads/2022/02/Final%20Annual%20Report-MPEDA.pdf

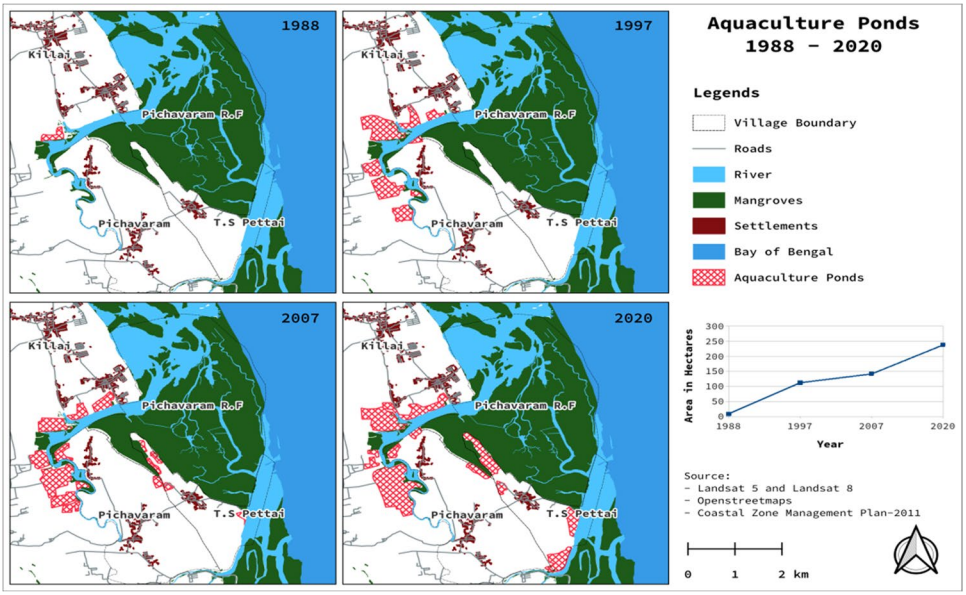

Fig. 1 Decadal expansion of brackish water shrimp aquaculture in Pichavaram and Thandavarayancholaganpettai (T.S. Pettai) villages

Aquaculture and the making of a saline landscape

How did aquaculture spread in Cuddalore district and our study villages? What we know is that aquaculture made its presence in the northern and southern parts of Cuddalore district in the early 1980s. Verdonk (2018), in a study of aquaculture in the northern part of Cuddalore district, argues that people first practiced "extensive" aquaculture by introducing shrimps from the backwaters into their agricultural lands but now much of the aquaculture is also on common lands along the river banks. In the southern part of the district, where our case study villages are situated, however, there is no evidence of such a history. Rather, in the late 1980s, the Killai backwaters were identified as a potential site of brackish water shrimp aquaculture, both pond-based and pen-based (BOBP 1987). *Penaeus monodon* (Tiger Prawn) was introduced in semi-intensive and intensive forms of aquaculture (Beutler 2017). In the early 1990s, aquaculture was confined to a small area around Killai, Radhavilagam and Pichavaram. By the early 2000s, aquaculture had also picked up in the Mudusolai area and expanded significantly around Pichavaram due partly to training sessions conducted with farmers by CIBA[8] and MPEDA.[9] Post-tsunami, further growth took place, especially in the village of T.S. Pettai (See Fig. 1) with *Litopenaeus vannamei* (Pacific White-leg Shrimp) becoming the dominant species. According to current data from the Coastal Aquaculture Authority (CAA), there are now 151 registered aquaculture farms in Cuddalore district today, the vast majority of them in the southern part of the district.

To understand why the Killai region was selected, it is necessary to engage with the issue of salinity. There are a number of studies on water quality in this region that highlight the high saline content of water in the coastal areas of Cuddalore (Aravindan and Shankar 2011; Gopinath et al. 2016; Sajil Kumar 2016; Gopinath et al. 2019) using different indicators including total dissolved solids (TDS), chloride (Cl) and electro-conductivity (EC) amongst others. These studies attribute high levels of salinity to a number of factors including sea water rises, increased groundwater extraction and even aquaculture itself (Jayanthi et al. 2018). All these studies, however, cover a large area, even a full district or two and are not temporal in nature, i.e., they do not analyze changes in salinity, and hence inadequately capture the more micro-village level processes that might have led to increased salinity.

To capture those processes, we honed in on two villages in the southern part of Cuddalore district, T.S. Pettai and Pichavaram (see Fig. 2). Both the villages are located close to each other and are in proximity of the Uppanar river. The villages are thus part of a backwater, saline ecosystem. The backwaters are an important breeding ground for fish, molluscs and crustaceans. However, the Uppanar river has also been a major source of irrigation to villages in the region. Recently, the available irrigation water in the system has declined. Two oft stated reasons for the decline are the inter-state conflict on sharing of Kaveri waters and the neglect of maintenance of the irrigation system (Ferdin 2010, Bijker 2007, Mollinga 2001, Folke 1998).

[8] http://www.ciba.res.in/wp-content/uploads/2022/07/annualReport_english_2021.pdf

[9] https://mpeda.gov.in/wp-content/uploads/2022/02/Final%20Annual%20Report-MPEDA.pdf

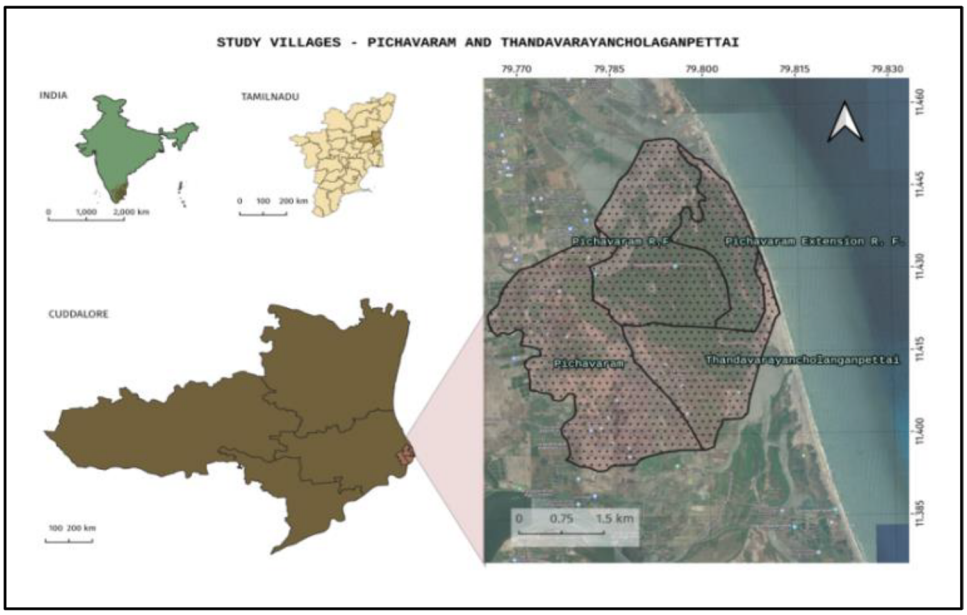

Fig. 2 Location of two case study villages – Pichavaram and T.S. Pettai

T.S. Pettai, in 2011,[10] had 306 households and a population of 1243 people. While T.S. Pettai is a multi caste village, fishers (Paruvatharajakulam) are numerically and socio-politically dominant. It is said that fishers bought land from agrarian communities who previously owned much of the land. Fisher households live mostly in the three main lanes towards the northwest of the village. Fishers in T.S. Pettai traditionally fished in the river all throughout the year and seasonally engaged in venturing into the sea. Until two decades ago, many fishers had makeshift residences seasonally on a small stretch of land mass between the Uppanar river and the sea, namely in Kodiyampalayam, Chinnavaikal, Pillumedu and MGR Thittu, as it gave them better access to the sea. Fishers told us that they had a system in place that allowed the four main clan groups access to different parts of the river.

T.S. Pettai, unlike most other "fishing" villages in Cuddalore district, not only also has a number of agricultural castes, predominantly Vanniyars, but also Mudaliars and Pillais. Of the two lanes running south in the village, one is inhabited mostly by Vanniyars and the other by Pillais and a few Mudaliar households. There are also Scheduled Castes (SCs) (Parayars), who account for 18.18% of the population and Scheduled Tribes (STs) (Irulars) who comprise 8.61% of the population. The SC community resides mostly in the northern side of the village and the ST population in the east.[11] Agricultural lands are situated mostly to the south of the village and on the western side near Kannagarapattu village. It is important to point out that Parayars and Irulars also subsist by catching backwater fish, crustaceans and molluscs, although they do not have "traditional" rights like the fishing community has.

Pichavaram is a neighboring village located to the northwest of T.S. Pettai. It is double the size of T.S. Pettai in area and almost three times as large in terms of population: there were 873 households and a population of 3463 in 2011. Pichavaram has eight hamlets, viz., Elantherimedu, Chengi Colony, Kaduvetti, Manalmedu, Nadupalayam, Setthukollai, South Pichavaram and North Pichavaram. Numerically, Vanniyars out-number other communities and are the main owners of agricultural land. However, there are also a few Naidu, Pillai and Mudaliar families who own agricultural land. The SC population of Pichavaram accounts for 15.20% of the population whereas the ST population only for 4.01%. Both SCs and STs engage in agricultural labor, menial work and glean for fish in the backwaters.

We focused on North Pichavaram where the aquaculture farms are mostly located. Except for 24 households of Irulars (ST) who live in the extreme north of the village in tsunami rehabilitation housing, the remaining 300 households or so are Vanniyars. Vanniyars own most of the agricultural land, including the land near the Uppanar river which runs parallel to the hamlet. Paddy and groundnut have been the main crops in the past, but some families near the Uppanar have now taken to shrimp aquaculture. Just south of North Pichavaram is the tail-end regulator which is key to the story of aquaculture.

The Uppanar river, which flows near these two villages, is part of the wider Kaveri delta irrigation system and receives water from the Kaveri river and the Veeranam Tank which is

[10] This is the last year for which official population data is available.

[11] In India and Tamil Nadu, caste is an important social category. Castes are divided into SCs, STs, backward castes (BCs), most backward castes (MBCs), and forward castes (FCs). BCs, OBCs, SCs, and STs are the socially disadvantaged castes. SCs or Dalits are the most excluded and in Tamil Nadu often inhabit separate "colonies." STs are Adivasis or tribals. While Vanniyars are MBCs, they often own considerable amounts of agricultural land.

located inland to the west. The Khan Sahib Canal (Palaman river), which was constructed in the eighteenth century to irrigate 40,000 acres of land in Chidambaram Taluk (*Manual of South Arcot District* 1853), emerges from the Veeranam Tank and continues to be a source of irrigation in our case study area. The Uppanar river, however, also connects to the brackish backwater of the Pichavaram mangroves. It thus acts as a confluence between fresh and brackish water systems. Locally, in the Pichavaram area especially, people talk about decreasing flow in the canal irrigation system. This might be due to more micro causes such as poor maintenance of the irrigation system and more macro causes such as the inter-state water dispute between Tamil Nadu and Karnataka over Kaveri river waters as mentioned above (Janakarajan and Joy 2011 and Folke, 1998). More importantly, people talk about the changing fresh water-brackish water equilibrium and increasing salinity. One reason for this, we believe, and seconded by some villagers, is the construction in the early 1970s of a tail-end regulator near North Pichavaram so as to check the tidal influence of the backwater in the upstream regions of the river (Pompoes 2022). The tail-end regulator enabled the diversion of fresh water through a number of minor canals so as to continue to provide fresh water for irrigation upstream. International donors, such as the Asian Development Bank, and the Union and State governments have invested in strengthening canal irrigations systems and maintaining these tail-end regulators (Pompoes 2022: 55). However, in Pichavaram, the tail-end regulator which was constructed almost 40 years ago by the Public Works Department (PWD) in order to redistribute fresh water of the canal irrigation system by preventing the saline inter-tidal water from adversely impacting irrigation, has actually blocked the natural admixture of fresh water into brackish water and therefore hampered fresh water intake and leaching away of salt,[12] making North Pichavaram more saline and accommodative of brackish water aquaculture.

In T.S. Pettai particularly, many locals also spoke about how salinity increased soon after the tsunami. Although the inundation of land and the retreat of the sea was a quickish event only lasting a few minutes (Violette et al. 2009), it appears from local anecdotes to have been a turning point in terms of the salinization of local livelihoods. A number of other studies make a similar point vis-à-vis increased salinity post-tsunami (Chandrasekaran et al. 2008; Kume et al. 2009; Violette et al. 2009; Villholth and Neupane 2011). This can perhaps be explained by the fact that the sea water which came inland during the tsunami seeped into the local aquifer. Moreover, given that there has been a decreased flow of freshwater in the upstream of the Uppanar river, this saline water was not flushed out adequately. Over time, as more aquaculture farms have been built, more saline water has been introduced into the landscape.

[12] Crops cultivated by canal irrigation water will have a minimum concentration of salt in them. Crops use up the irrigated water in the process of evapo-transpiration and leave behind salt in their roots. However, this negligible amount of salt is removed by the process of leaching wherein the salts are leached into the soil by addition of fresh water.

Are aquaculture owners small farmers?

CAA data shows that there are 18 aquaculture farms in T.S. Pettai covering an area of 19.49 acres, or just over 1 acre per farm. These farms are located in the southeast and northwest of the village. The 18 farms comprise a total of 74 ponds, meaning that each owner has on average about four ponds. Ten of these 18 farms are owned by people living in T.S. Pettai and eight by people outside of T.S. Pettai. Some of the non-local owners are based in Nagapattinam, a district south of Cuddalore, but according to our field enquiries they partner with local people to run the farm. Other owners from outside T.S. Pettai are based in other parts of Cuddalore district, including one in Killai where aquaculture first started in the region. Pichavaram, on the other hand, has 19 registered farms comprising an area of 21.08 acres, located in the western part of the village near the Uppanar river. Out of these 19 farms, 9 are owned by people living in Pichavaram, mostly North Pichavaram, and 10 by people living outside of Pichavaram. Seven of the non-local owners are listed as being residents of T.S. Pettai, but when we enquired about this people denied it.

To what extent small farmers have benefited substantially from brackish water shrimp aquaculture as policy discourse suggests is our next concern. In the Indian context small farmers would include those who have less than 2 ha (or 5 acres) of land. The term small farmer, as defined in the Agricultural Census, actually refers to those who have 1–2 ha of land, but in our analysis we also include marginal farmers who have less than 1 ha of land. As mentioned earlier, brackish water shrimp aquaculture is a sensitive topic because it is associated with environmental problems and illegalities around CRZ. Regarding the category of small farmers, it is important to note that household livelihoods have significantly diversified and hence the economic position of a household might not be captured well by only looking at their total extent of agricultural lands. In fishing villages such as T.S. Pettai, especially, people fish and many people have migrated to the Gulf to work on boats or to the Far East for construction work. Though these jobs are often low end jobs, there are households, as we illustrate below, who have diversified outside of agriculture and/or also have good political and social capital.

In Table 1, we give details of the eight aquaculture owners from T.S. Pettai and Pichavaram (four from each village) from whom we got relatively detailed information. A

Table 1 Characteristics of owners in the study region (numbers instead of names are used in order to veil the identity of respondents)

Owners	Villages	Important details about aquaculture farm owners
1	T S Pettai	• Belongs to fishing community in the village. • Owns more than 10 shrimp farms. • Remittances from his earlier occupation in Dubai. • A taluk level leader in a prominent political party in Tamil Nadu (Dravida Munetra Kazhagam - DMK). • Owns a feed retail distribution agency within the village. • Owns two hectares of agricultural land. • Owns a STB (Stern Trawl Boat) and other trawlers berthed at Pazhayar fishing harbor.
2	T S Pettai	• Owns a one hectare unlicensed shrimp pond. • Invested his remittance from abroad • Owns 4 acres of agriculture land. • A prominent DMK leader. • Close associate of Owner number 1.
3	T S Pettai	• Is a professor at a nearby university (Annamalai University). • Wife also a professor at the University. • Owns a pond. • Kin of Owner number 1.
4	T S Pettai	• Her brother was an ex-Panchayat President. • Owns four shrimp farms. • Has two acres of agricultural land.
5	North Pichavaram	• Was Ex-Panchayat President. • Acted as a land negotiating broker in the initial introduction of shrimp farms in the region. • Has six and half acres of land under shrimp aquaculture near the Uppanar river. • An ex-service man, voluntarily retired for Indian para- military service. • Served in Singapore for 5 years. • Currently, two sons are in Singapore. • Engaged his youngest son in Shrimp farming who is politically active in the All India Anna Dravida Munnetra Kazhagam (AIADMK) — another prominent political party in Tamil Nadu. • Four acres of agricultural land in Kanagarapattu.
6	North Pichavaram	• His wife is the Panchayat President of Pichavaram Revenue village. • Owns a one hectare pond in the village. • Is a village level cadre of the AIADMK.
7	North Pichavaram	• Currently the Councilor of North Pichavaram hamlet. • A prominent taluk level leader in AIADMK. • Had been to Singapore for 3 years. • Holds more than 19 acres of agricultural land. • Owns three shrimp farms along the banks of Uppanar river. • One of the prominent land holding families in the village.
8	North Pichavaram	• Has leased a hectare pond from a person who is an outsider. • Had invested his remittances from abroad in shrimp farming.

number of things are apparent. First, as mentioned above, many of those who have invested in aquaculture farms have significant capital, either locally or from working abroad. Thus, Owner number 1 in T.S. Pettai, a member of the fishing community, not only has agricultural land, but also owns a steel trawl boat berthed in neighboring Nagapattinam district and a feed retail distribution company. Owner number 3 is a relation of Owner number 1 and is a Professor at Annamalai University in Chidambaram, a town approximately 15 km away. Owner number 5, in Pichavaram, is an ex-service man and was a land broker in the early phases of aquaculture in the region. He also worked in Singapore for

5 years and has two sons working there presently and thus is able to put more than six and half acres[13] under aquaculture. Similarly, Owner number 7 is one of the biggest landowners in Pichavaram (nineteen acres of land) and also spent many years working in Singapore. Thus, agriculture is clearly not their only or main source of income.

The other noticeable feature is that almost all of the aquaculture farm owners are politically well-placed, barring perhaps Owners number 3 and number 8 who are not directly involved in politics. Owners number 1 and number 2 are active members of the Dravida Munnetra Kazhagam (DMK), one of the two regional Dravidian parties, at the taluk- and village-level respectively. Owners number 5, number 6, and number 7 are with the other major Dravidian party, the All India Anna Dravida Munnetra Kazhagam (AIADMK). Political connections go a long way in India and in Tamil Nadu as they foster strong networks that are important in accessing capital and obtaining licenses as would be the case with aquaculture. The fact that many of the aquaculture owners are not only members of the two main political parties but also hold elected posts locally or are related to members who hold such posts is worth noting. Owner number 4's brother used to be panchayat president in T.S. Pettai. Owner number 5 used to be panchayat president in Pichavaram and Owner number 6's wife is currently panchayat president in Pichavaram. It is also important to point out that all aquaculture farm owners in Pichavaram are Vanniyar.

Adverse impacts of aquaculture

What is also clear from our fieldwork is that brackish water shrimp aquaculture has a number of adverse consequences, many of them linked to salinity. The presence of aquaculture farms has resulted, according to villagers, in stagnant saline water being very prominent in the physical landscape. Moreover, during the three to four month cycle of shrimp cultivation, saline water seeps into the soil; farmers claim that this adversely impacts their paddy agriculture which is situated nearby. In Pichavaram, shrimp farms now inhabit land which three decades ago were fully under paddy. Villagers say that paddy cultivation becomes less prominent each year because of declining fertility of the soils. One woman in T.S. Pettai, who has land more than 600 meters away from aquaculture farms, says she is unable to cultivate paddy anymore. What paddy does remain is now almost entirely dependent on bore-well irrigation. In Pichavaram, farmers grow groundnut which is more tolerant of salinity. However, people told us in both villages that the productivity of land had declined significantly, even in the case of groundnut cultivation. A women from Pichavaram said a couple of years back her family produced 55–60 sacks of ground nuts, each of 50 kg, in their 1.5 acres land in the eastern part of the village, but it had now declined to 42–45 sacks. In Pichavaram, moreover, the story was also about shortened agricultural seasons (paddy is grown for three months during the northeast monsoon) and changes in cropping pattern (as paddy declines, groundnut becomes more prominent). On the other hand, in T.S. Pettai many had abandoned agriculture altogether and migrated to nearby towns and cities for construction work. In Pichavaram, procuring palmyra ice apples during the months of April, May, and June (summer season) has become a routine livelihood source. With aquaculture continuing to grow, the likelihood is that more agricultural land will be impacted. Our findings are echoed by earlier studies dating back to the 1990s. Vandergeest et al. (1999), in their study on Thailand, illustrate how brackish water leakage from aquaculture farms adversely impacts neighboring paddy fields and kills sugar palm trees within the paddy fields. Paprocki and Cons (2014), in another study in Bangladesh, illustrate how aquaculture adversely impacts home gardens near to homesteads as a result of increased insect presence and hence use of pesticide.

In terms of agricultural allied activities, grazing in the village is impacted. Cattle and livestock used to graze on their own private lands or on lands of others. But with agricultural lands declining significantly, they now have to travel longer distances, sometimes as far as 5 km to do so. As elderly people often take the cattle for grazing, the activity has become very arduous for them and can take the full day.

Aquaculture has also adversely impacted fisheries, the other main livelihood in T.S. Pettai. Fisher households mentioned that effluents from the ponds had resulted in the decline of availability of fish in the Uppanar river. They also told us that previously they were able to recognize and identify the type of fish and where particular fish could be located in different seasons based on the high tide and low tide. They refer to the availability of fish resources in high tide and low tide as *kanisam*. However, with the discharge of effluents into the Uppanar, the *kanisam* has become completely unpredictable. Local fishers claim that a wide variety of native prawn species such as *vallicharaal* (brown shrimp – *Metapeneaus monoceras*), *venraal* (white prawn – *Peneaus indicus*), *cemmaraal* (brown shrimp – *Metapeneaus sp*), *motraal* (scampi – *Macrobrachium sp*. (hind-limbs and mandibles are bigger in size)) and *karumraal* (tiger prawn – *Paneaus monodon*); mud crabs species (*Scylla serrata*); and some fish species such as mullet (*Liza dussumeri*) and catfish (*Liza tede*) have drastically reduced. In T.S. Pettai, fishers and SC and ST communities who mostly glean for fish echoed similar concerns to those of the fishing community. Irulars are now forced to illegally glean for polychaetes

[13] There are 2.47 acres to a hectare. Hectare is the unit used more commonly, for example to classify farmers as marginal, small etc. However, farmers provided details in acres.

which are increasingly in demand as feed in aquaculture hatcheries. They complained that polychaete production also had significantly reduced because of this same untreated water being released into the backwaters. Moreover, they mentioned that they had developed athlete's foot and skin related diseases while gleaning during that time of the year when shrimp ponds release their waste. The adverse income effect of lost livelihood opportunities, despite health risks, has meant that Irulars are more and more dependent on micro finance institutions (MFI's). Other studies by Vandergeest et al. (1999) in the context of Thailand and Hadjimichael et al. (2014) in the context of Cyprus make similar claims about the adverse impacts of aquaculture on fisheries.

Signs are that there are also negative impacts on the wider ecosystem. Both our case study villages are situated close to Pichavaram mangrove forests. Effluent discharge, villagers argue, has resulted in the thinning of the density of mangrove forests. This narrative is in line with Kathiresan's (2002) findings that Pichavaram mangrove forests have been degraded due to increased salinity and loss of soil nutrients. Jayanthi et al.'s (2018) study, using Landsat imagery, illustrates that brackish water shrimp aquaculture on the eastern coast of India, including Tamil Nadu, has resulted not only in the loss of mangroves but also mudflats and saltpans. Ahmed and Glaser (2016) illustrate similar impacts of brackish water aquaculture on mangroves in multiple countries other than India, namely Brazil, China, Malaysia and Indonesia.

Increased salinity levels in our case study villages have also meant that the quality of groundwater has deteriorated to the extent that a number of household activities have been badly affected. Poor drinking water was the main complaint. In T.S. Pettai, SC and fisher households, located mostly in the northern part of the village, complained the most of increased salinity levels. One woman expressed that drinking water had become so bad that all aquaculture farms should be closed down if things were to improve. In T.S. Pettai, women whose ground water wells or hand bore pumps have become saline often collect drinking water from the single hand pump near the temple in the center of the village, often spending hours doing so because of long queues of women. The Irular settlement, which is located more than 600 m away from the rest of the village, had a water purifier installed but it remains dysfunctional. Hence, Irular women also depend on the temple hand pump. In Pichavaram, things are similar with two hand pumps providing good water located at two extremes of the village. Although the government installed a number of hand pumps in Pichavaram, water quality remains poor and women residing in the center of the village have to walk at least a kilometer to fetch decent quality drinking water. The worst affected are landless SC and ST women.

Non-compliance of shrimp farms

The CAA was established in 2005 as result of the Coastal Aquaculture Authority Act of the same year. The main aim of CAA was to regulate coastal aquaculture so as to take a precautionary approach to development and further sustainable development. More specifically, CAA's role was to oversee the construction of ponds and their operation, monitor the registration of ponds, provide input and effluent standards and ensure Environment Impact Assessment (EIA) s are undertaken for those farms that require it. All aquaculture farms in the coastal area were mandated to register with the CAA. Moreover, it was to ensure that land meant for public purpose, e.g., village common land, salt pans and mangroves should not be converted into aquaculture farms.

In practice, however, many aquaculture farms are not registered with the CAA nor do they have licenses. According to CAA records of the licensed farms, only two aquaculture farms in Pichavaram and four in T.S. Pettai are "active" but clearly in reality many more are. It is unclear what this means. Have the owners of these farms not renewed their licenses? Or is it that the CAA has not diligently recorded aquaculture farms? What we also noticed is that some aquaculture farms occupied *poromboke* or common lands Fig. 3.

The CAA Act also mandates spacing between adjacent ponds, safe distance from village habitations, ecological sensitive areas, agriculture land and water sources. In Pichavaram, ponds are observed as clusters and located within 200 m of the hamlet, violating the Act's provision that for villages of more than 500 people farms should be more than 300 m away. In T.S. Pettai, ponds in the north and south of the village are located on the banks of Uppanar. Furthermore, clusters of ponds do not have the adequate 20 m spacing between them nor have they undertaken environmental impact assessments. We also observed that effluents from ponds are released into the estuary. Equally significant, many of the farms are located within ecologically sensitive areas as classified by CRZ. This raises a number of questions. Have amendments been made to the CRZ again to allow for these farms or are these farms illegal? What has happened to the precautionary principle that should guide environmental policy making?

Given the numerous adverse socio-economic and ecological impacts of brackish water shrimp aquaculture in this region, it is puzzling as to how these farms continue to operate. It also raises questions because the justification for aquaculture has often been in terms of livelihoods, food and nutrition, none of which have been provided significantly in these two villages. As Immanuel (2019) points out, only rejected export produce are sold in local markets.

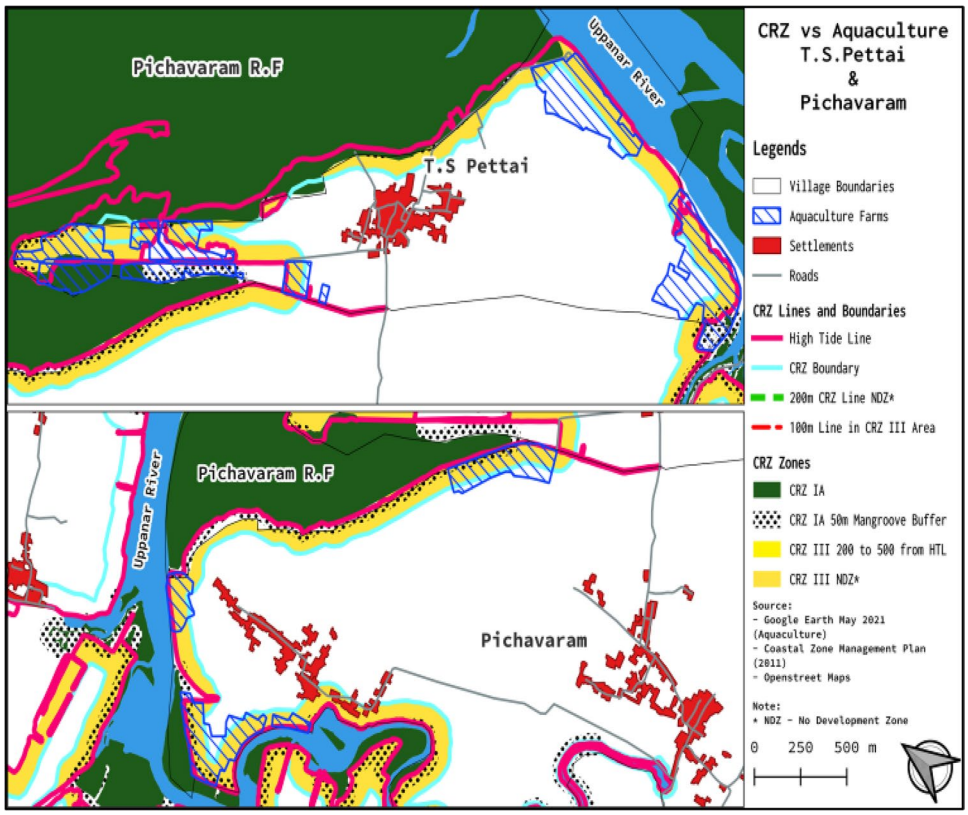

Fig. 3 Aquaculture farms extending into the regulated CRZ areas

Discussion

We have illustrated three main points in our analysis of brackish water shrimp aquaculture. First, there are significant limits to the veracity of the discourse on aquaculture that sees it as an important source of livelihoods and food security that require attention. While livelihoods, food security and nutrition have been primarily invoked as a defense for aquaculture, brackish water aquaculture is predominantly shrimp-based and targeted for export markets. Therefore, although some shrimp is circulated within the local markets and possibly can address local food security needs, the vast majority travels globally. CIBA's Vision 2050 document says the following:

While acknowledging the economic gains and employment opportunities provided by the brackish water aquaculture sector, it is essential to recognize the skewed growth of brackish water aquaculture towards monoculture of shrimp…… Modern aquaculture is profit-driven and governed by free market principles (CIBA 2015: vii-viii).

Profits are to be made through export and not for the most part in local markets. Moreover, though CIBA talks about diversifying brackish water aquaculture to different types of shellfish and finfish, little of this has happened thus far, raising questions with regard to how brackish water aquaculture can meet local food security and nutrition needs. It also raises similar questions about the Blue Economy and the role brackish water aquaculture can play in realizing SDGs given its well-documented adverse environmental impacts. As Koshy (2021) points out, uncontrolled expansion of brackish water aquaculture will adversely impact the livelihoods of local communities and lead to the degradation of community resources.

The other discursive limitation is that of salinity. While proponents of brackish water aquaculture recognize that brackish water shrimp aquaculture can result in increased salinity, salinity is "naturalized" and seen to be endemic to coastal areas. Overly saline agricultural land is treated as "uncultivable" and alternative livelihood options are sought outside of agriculture. However, questions are not adequately asked about how salinity has increased, attributing increase mostly to "natural" events such as seawater intrusion. What we have tried to illustrate is how state interventions, in particular in the form of the tail-end regulator, has adversely impacted the salt water-fresh water equilibrium and made downstream areas more saline. Coastal communities have always lived with a certain degree of salinity; however, the increase in salinity levels as perceived by farmers has made agriculture less, if not totally, viable.

Second, the evidence is weak with regard to small farmers benefiting from brackish water shrimp aquaculture. Based on our limited sample of aquaculture farm owners, it appears as if economic, political and social capital are,

if not pre-requisites for enabling people to be aquaculture owners, certainly important influencing factors. The extent of agricultural land a farmer has appears, therefore, to be less important than the investable capital and contacts that he has. The other important factor is location. Most of the aquaculture farms have sprung up near the Uppanar river or the backwaters. However, in the longer run, it is possible and even likely that changing salinity levels will result in other lands further inland coming under aquaculture as farmers proclaim that they are too saline for agriculture. In that sense, as we argue, livelihoods are increasingly becoming salinized.[14]

Third, with aquaculture likely to expand further, it is important to point out that besides for its adverse socio-ecological impacts, there are few signs that it will be employment generating. A quick look at official data will help us explain this claim. Recent FAO (2020: 36–37) data for 2018 points out that 20.53 million people worldwide were employed in aquaculture. This is a substantial increase from the 7.88 million people employed in aquaculture in 1995. However, we know that fresh water aquaculture contributes a majority of total output in aquaculture; hence, it is likely that it also accounts for a lion's share of the employment. Another issue worth pointing out is that employment can include full-time, part-time, and occasional employment and vary from permanent to temporary to seasonal. The FAO is only now starting to collect more data on employment in aquaculture, its gendered nature (Kruijssen et al. 2018) and the contribution of the primary and secondary sectors within aquaculture. Such data is critical to assessing the employment opportunities within aquaculture as a whole and brackish water aquaculture more specifically. From our case studies, however, what we know is that unlike agriculture which is a relatively labor-intensive occupation, aquaculture owners employ on an average three individuals in their farms and that too mostly during harvest. Women are employed only in a few aquaculture farms to cook for the farm workers. Our concern about lack of employment generation locally has been echoed in other studies of brackish water aquaculture in Tamil Nadu too (CRC 2020).

It is also worth pointing out that brackish water shrimp aquaculture in particular is targeted primarily to the export market and hence other "local" benefits such as food security and nutrition are also absent because most of the shrimp goes to far away markets. This raises questions, at least at the regional scale, with regard to making brackish water shrimp aquaculture a thrust area because it benefits mostly those with political and economic capital with few other benefits to the local economy.

[14] By this, we mean that choices about livelihoods and meeting basic needs are influenced by the salinity of water and land.

Ironically, a number of people we spoke to, especially in T.S. Pettai, told us that they would switch to aquaculture if they had the necessary capital to do so. There is a Maria's paradox (Arsel et al. 2019) of sorts in the making in villages such as T.S. Pettai and Pichavaram where aquaculture is increasingly spreading and adversely affecting people's lives but yet these same people see in it a possible livelihood alternative. Increasing salinity levels, at least in the minds of local people, appear to be irreversible in the short-run and hence adopting aquaculture is seen as a more beneficial option. However, the number of people involved in aquaculture remains minimal. If the adverse environmental impacts of semi-industrial brackish water shrimp aquaculture are included, the situation looks more bleak, a long way away from a more diversified, sustainable livelihood strategy that policy pronouncements talk about.

Conclusion

This paper, adopting a political ecology approach, has taken issue with the discourse and materiality of brackish water shrimp aquaculture, questioning whether or not it provides a viable source of livelihood, food security and nutrition for small farmers in saline coastal ecologies. We have suggested that the enthusiasm over aquaculture as a whole, namely fresh water and brackish water, runs the risk of erasing the significant variations, both regionally and substantively, that exist with regard to aquaculture and ignores in particular the fact that brackish water shrimp aquaculture is as much a cause of increased salinity as it is a solution to it. After highlighting the significant state investment into aquaculture research and the growth of aquaculture internationally and in India, the paper focused on the expansion of brackish water shrimp aquaculture in two villages, T. S Pettai, a fishing village, and Pichavaram, an agrarian village, in Cuddalore district of Tamil Nadu, India. We argued that the construction of a tail-end regulator in the 1970s for irrigation purposes was an important factor in changing the saline-fresh water mix of the Uppanar river and backwaters and consequently a cause of increased salinity in the area, providing the conditions for brackish water shrimp aquaculture to emerge. The 2004 tsunami further increased salinity, resulting in a second wave of brackish water shrimp aquaculture in the region.

Our detailed case studies also illustrated a couple of other important points about brackish water shrimp aquaculture in the region. First, we illustrated that it is problematic to argue that small farmers have benefited significantly from aquaculture. While it was difficult for us to verify the actual extent of agricultural land owned by aquaculture farmers, many of them by their own admission had more than 2 ha of land (the upper limit for a small farmer) or in the case of some fishing households

large mechanized trawlers. Equally important, most of the aquaculture farmers we spoke to had significant political clout and were active members in one or the other Dravidian political party. Second, in both villages, the gradual expansion of aquaculture brought with it a number of environmental and socio-economic problems. Agricultural land has become less productive with the area under paddy cultivation significantly declining and grazing lands have shrunk as more land is put under aquaculture. Fishing and gleaning have been adversely impacted by the release of aquaculture farm effluents in the backwaters and river. And drinking water has become very saline, forcing women especially to walk longer distances to collect drinkable water and some to even buy water.

Brackish water shrimp aquaculture has been controversial from the outset in India because of its location near the coast. We illustrated in this paper how shrimp farms have in a number of ways violated CRZ notifications. Not only do shrimp farms border habitations, something against the law, but they are also located in the vicinity of ecologically sensitive areas such as Pichavaram mangroves and in "no development zones." This despite the fact that a coastal aquaculture authority was formed in 2005 with the particular mandate to regulate aquaculture farms, something that appears not to have happened if the number of unlicensed farms is anything to go by.

All these concerns raise doubts about the future and potential of brackish water shrimp aquaculture. On the one hand, only households that have significant capital are likely to be able to invest in aquaculture. Given that shrimps are primarily intended for the export market, it is unclear as to how shrimp aquaculture will provide food and nutrition benefits locally, unless increased incomes result in better nutritional investment. On the other hand, and more importantly, investment in brackish water shrimp aquaculture is likely to further amplify the adverse environmental impacts. Here, the question of reversibility is important. Can salinity be reduced and would there be any incentives to do so given the continued large export potential of shrimp? How could CIBA translate its mandate to diversify brackish water aquaculture if shrimps continue to be the most lucrative? Ironically perhaps, many households we spoke to said they would take up shrimp aquaculture if they had the capital to do so because agriculture had become very unproductive. Given the scenario we have described in T.S. Pettai and Pichavaram, this is extremely worrying both from a socio-economic and environmental perspective.

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Declarations

Conflict of interest The authors declare no competing interests.

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