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Technical and Environmental Analysis of Shrimp Farming in the Coreaú River Estuary, Cear ά State, Brazil

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Abstract

Compared with other countries, the Brazilian shrimp aquaculture had a moderate development occupying an area of less than 20,000 hectares. Despite the importance of shrimp farming in rural economy developing, many critics unproven technical and/or scientific have been made due to possible environmental and social impacts of this industry. The objective of this study was to evaluate the technical, social and environmental aspects of shrimp farming in the Coreaú river estuary, Ceará, Brazil. The focus was on the operating characteristics of shrimp farms. Results indicate that no shrimp farm was constructed on mangrove areas and no significant environmental impacts regarding water pollution were detected. However, it is interesting to identify technologically and economically feasible options for to resolve or mitigate the negative environmental impact of a future expansion of shrimp farms in this region.

Keywords: Shrimp farm; Mangroves; Impacts; Environmental; Penaeus vannamei

Introduction

Global production of white shrimp *Penaeus vannamei* increased rapidly from 2.2 in 2008 to 2.7 million tons in 2010, at an average annual rate exceeding 10.2% [1,2]. Historically, shrimp farms started developing rapidly in early 1980s in response to international market demand and supported by government policies in many tropical and sub-tropical countries [3-6]. Shrimp farming industry has often been promoted in developing countries by means of diversification of economy, technological transfer, rural employment and foreign exchange [3,7-12]. On the other hand, shrimp farming has been historically related to negative environmental impacts including large-scale degradation of mangroves, alteration of wetlands, land subsidence, salinization of ground and surface water, pollution of agricultural lands and coastal waters by pond effluents and sludge, introduction of exotic species or pathogens into coastal environment and subsequent loss of goods and services generated by natural common property resources [13-25].

In Americas, this industry was responsible by 20% of the world's shrimp production. Leading producers of farmed raised shrimp in western hemisphere include Ecuador, Mexico and Brazil [26]. Brazilian production was estimated at 70,000 tons that generated US$ 280 million in 2010 [2]. In Brazil, semi-intensive and intensive shrimp farming began during the 1980s with introduction of the white shrimp *P. vannamei*, stimulated by international market demand for high-value shrimp. The northeast region of Brazil is responsible for around 97% of the country's shrimp production [27]. The national shrimp farm industry has been studied from different points of view considering several aspects such as technical, economic, social and environmental issues [13,28-39]. Contrastingly, little is known about benefits of Brazilian shrimp farms, despite the large number of scientific papers, technical manuals and management briefs [13,35,40].

Ceará state is one of most important aquaculture sites in Brazil, with total farmed shrimp production was 21,000 tons during the year 2010. An increase of 42.8% was noticed in farmed shrimp in 2011, with 30,000 tons produced [41]. Despite the importance of shrimp farming in developing the rural economy of the Ceará state, many unproven critics have been made regarding both negative environmental and social impacts of this industry. Therefore, further studies should be conducted to establish the coastal land occupation by shrimp farms and possible relationships with mangroves destruction, coastal pollution, shrimp diseases spread pond effluents, decline in food security and the marginalization of coastal communities. Coreaú river estuary is the third most productive shrimp farmed area in Ceará state. Currently, there are no studies reporting the environmental impacts of shrimp farms in this estuary. The aim of the present study was georeferenced shrimp farm areas by using satellite images and geoprocessing techniques, as well as to analyze both technical and environmental issues of shrimp farms in the Coreaú estuary, Ceará state, Brazil.

Material and Methods

Site location

This study was developed at marine shrimp farms located along the hydrographic basin of Coreaú river. The Coreaú river is part of the Atlantic hydrographic region of Brazilian northeast, located in the West region of the Ceará state and represents one of the main hydric reserves of the state with the enclosed area of approximately 4,400 km^2. Coreaú river estuary comprises significant areas of mangrove forest with approximately 100 km^2 and it is characterized by a great economic and ecological importance (Figure 1).

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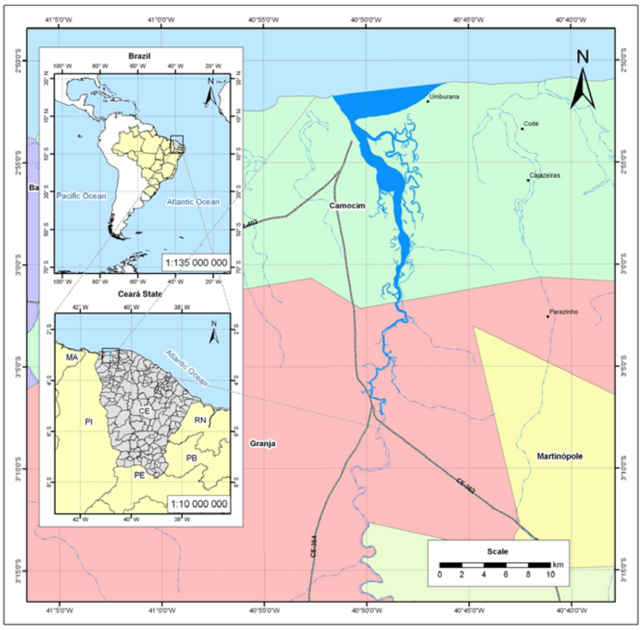

Figure 1: The study area: northeastern of Brazil.

Technical parameters

All shrimp farms were visited to collect information on the operating characteristics of shrimp aquaculture. This analysis was focused on shrimp production in ponds with particular attention to growout and harvesting phases in the production cycle [13]. The methodology was based on field observations, interviews, and analysis of secondary data [36]. A survey carried in the period 2010-2012 involved direct interviews using a semi-structured questionnaire. Interviewees included farm owners or managers, traders, processing plant managers, hatchery managers and government officials. Data analysis was based on field observations, interview transcriptions, and external sources including official documents, external sources and academic literature on the subject [42]. In addition, data about the benefits and problems of shrimp aquaculture were collected. The benefits include the creation of direct formal jobs, seasonal jobs, indirect formal jobs including hatcheries and post-harvest, earning of foreign exchange, diversification of the economy, stimulation of backward and forward-linked sectors, inflow of direct investment and technological transfer. The negative aspects of shrimp aquaculture include technical, environmental, economic and social problems.

Processing of satellite images

The applied methodology for shrimp farms identification was based on satellite images analysis with a resolution of 15 meters per pixel (Landsat 8). Images available in the online platform Google Earth (QuickBird) with high-resolution (2 meters per pixel) were used. Geometric correction was applied to remove image distortions introduced by the collection geometry. Afterwards, images were overlapped in layers using digital aerial photographs edited by the Directorate of Hydrography and Navigation (DHN) of Brazilian Navy in order to characterize the type of occupation and land use of the current aquaculture enterprises. These aerial photographs were obtained in the 1960s when there were no shrimp farms in Brazil. Subsequently, thematic maps in detail scales were developed by application of digital interpretation of images and GIS, available in software SPRING 4.2 and ArcGIS 9.0. By using image processing and classification results, it was possible to map and survey the land areas occupied by shrimp farming in the Coreaú river estuary.

Water sampling and analysis

For collecting the samples, nine shrimp farms were visited during eight sampling expeditions from January 2010 to December 2011. During the shrimp production season, a total of 72 and 144 samples were collected from shrimp farms at the pump station (influent) and point of water discharge (effluent), respectively. Water samples were stored in clean plastic bottles and returned immediately to the lab for analysis by applying standard methods. Water quality parameters were analyzed in the water samples [43]. The parameters included: temperature, pH, dissolved oxygen (DO), total ammoniacal nitrogen (TAN), ammonia, nitrate, nitrite, total phosphorus (TP), chlorophyll a, biochemical oxygen demand (BOD) and turbidity. The water quality data were examined an analysis of variance (ANOVA) followed by the post-hoc Duncan multiple range test. A probability level of $p<0.05$ was considered statistically significant. The values were expressed as the mean ± SD.

Results

The shrimp farming system

The number of shrimp farms in the Coreaú river estuary producing white shrimp *Penaeus vannamei* in earthen ponds has increased during recent years. Currently, the industry has only 9 participating farms (Table 1). The range size of farms in the Coreaú river estuary varied from 9 to 310 ha, with a mean estimated at 60 ha. The more common management system in the region is the semi-intensive type which occurs in 90.5% of the farms, while the intensive system comprises 9.5%. In this study, total area dedicated to shrimp farming was 670.1 ha in 2011 (Figure 2). The pond area was 539.3 ha (Table 1), while the remaining 130.8 ha refer to buildings, intake canals, pump stations, distribution canals and discharge canals. Additionally, information presented by three farmers indicates a production area expansion in over 370 ha, including the construction of a new shrimp farm in the period 2011-2013 (personal information).

Details on the management and characteristics of shrimp farms are summarized in (Table 2). The pond size also is variable (1.3 and 15.7 ha), 2–5 ha being predominant. The mean stock density for intensive shrimp farms is 40 PL/m and for the semi-intensive 20 PL/m. In 2010-2012, the survival was normally in the range of 60.2–95.9% from stocking to harvest. The shrimp farms operated all year round with 2.4 to 5.2 cycles/year. In 2011, the total production was 3,324 tons in a pond area of 539.3 ha with an average yield of 6.2 ton/ha/year. Different commercial feeds have different food conversion rates, but current feeds on the market have an average FCR between 0.7 and 1.5 for the growing conditions prevailing in this region.

Before each production cycle, ponds are emptied and the sludge is removed (both after harvest and before the new cycle) (Table 2). Depending on the natural conditions of each area, ponds may require further treatment before the new cycle. In the case of soil with pH acid, the treatment with dolomite – $CaMg(CO_3)_2$ and/or lime n CaO and/or slaked lime – $Ca(OH)_2$, is done to neutralize the acidity of the soil in the pond in the preparation phase. Typically, the dosage of dolomite and/or lime ranges between 1.0 and 3.0 ton/ha, depending on the soil pH. The ponds are then aerated continuously for two to five days, to kill vectors of infectious diseases such as fish and crabs. The ponds are disinfected with chlorine and then fertilized to promote algal production with urea

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Production system	Small		Medium		Large		Total	
	Number of companies	Area (ha)	Number of companies	Area (ha)	Number of companies	Area (ha)	Number of companies	Area (ha)
Semi-intensive	3	59.0	3	119.3	1	310.0	7	488.3
Intensive	1	9.0	1	42.0	0	0.0	2	51.0
Total	4	68.0	4	161.3	1	310.0	9	539.3

Table 1: Characteristics of the shrimp farms by size operation.

Characteristics	Intensity of farming systems	
	Semi-intensive	Intensive
Pond size (ha)	2.5-15.7	1.3-2.1
Stocking density (PL/m)	15-30	30-50
Survival rate (%)	75.1-95.9	60.2-84.2
Water exchange (%)	0-5	3-30
Aeration (HP ha^{-1})	0-4	4-12
Yield (ton/ha/yr)	5.9	8.1
Number of crops/yr	3.2-5.2	2.4-3.6
Production (ton/yr)	2912,1	412.1
Fertilizers used (ton/ha/yr)	Urea<0.25, TSP<0.03	Urea<0.50, TSP<0.10
Feed consumption (ton/yr)	2795.0	570.7
Feed used	Natural and pelleted feed	Pelleted feed
Protein feed (%)	40-30	40-35
FCR	0.8-1.2	1.3-1.5
Chemicals used	Yes	Yes
Direct formal jobs (persons/ha)	0.34	0.65
Direct seasonal jobs (persons/ha)*	0.06	
Indirect jobs (persons/ha)*	0.63	
Disease problems	Rare (IMNV and IHHNV)	Rare (IMNV and IHHNV)
Operational costs	Moderate to high	Moderate to high
Environmental impact	Relatively little	Relatively little
Social implications	Moderate to high	Moderate to high
Economic proliferation	Commercial	Commercial
Sustainability concerns	Moderate to low	Moderate to low

*The number of jobs was calculated the total area of shrimp farming (539.3 ha).

Table 2: Characteristics of the different types of shrimp aquaculture practices.

and phosphate (or super phosphate). The quality of the water before stocking shrimp larvae have to meet the guidelines for white shrimp farming, and should be maintained throughout the cultivation season.

Shrimp culture industry in the Coreaú river estuary generated an average of 1.05 direct formal jobs, seasonal jobs, indirect formal jobs including hatcheries and post-harvest per hectare (Table 2). Shrimp farms are responsible for the generation of 197 direct formal jobs and 30 seasonal jobs related to shrimp harvest. The other secondary activities including shrimp buyers and small processing plants have generated 338 direct formal jobs. The employments generated by fertilizers and feed industries were not considered because they are not located in the region of Coreaú river estuary. The local population is the main beneficiary from jobs created. However, skilled jobs are frequently offered to outsiders. Additionally, this industry has contributed to the strengthening and diversification of the local economy, increasing in the number of jobs in other sectors of industry and commerce.

Currently, the states of São Paulo, Rio de Janeiro, Minas Gerais, Bahia, Ceará and Pernambuco are thought to be largest shrimp consumers in Brazil, with practically 100% of production directed to the domestic market. Many shrimp producers trade to processing plants, while some producers realize sales of smoked shrimp for the Pará state. Afterwards, depending on commercial demand, processed shrimp is removed from the storage chambers and shipped by land

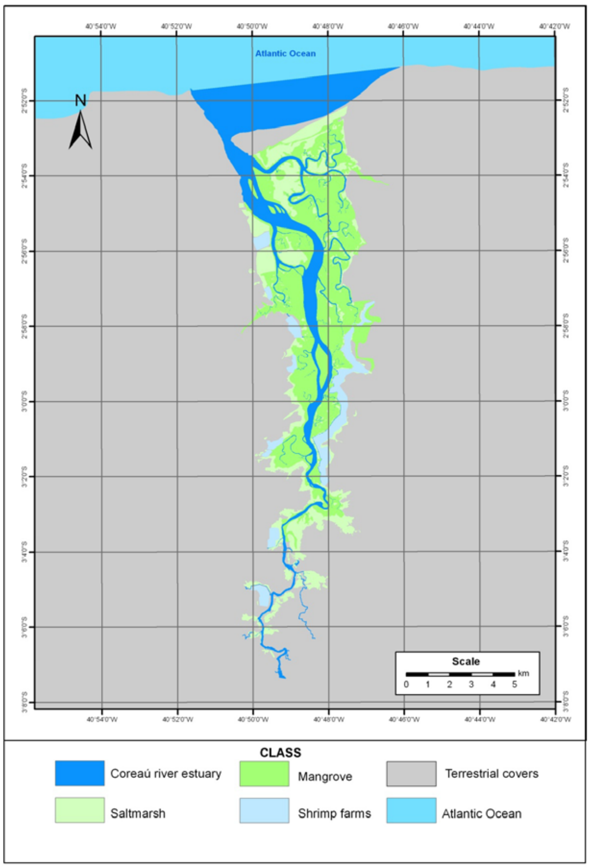

Figure 2: Thematic map of coastal wetland distribution in Jaguaribe river estuary. Land cover categories obtained by digitisation and by means of a supervised classification for Landsat Geocover of 1999-2000, CBERS of 2009-2010 and Google Earth images.

to consuming centers in Brazil. However, there are some direct sales to other customers such as supermarket chains, stores, hotels and restaurants. Therefore, the farmed shrimp industry has not favored foreign currency in the country.

Assessment of land cover and land use

Polygons for Coreaú river estuary, saltmarsh, mangrove, shrimp farms, terrestrial covers and the Atlantic ocean were digitised on-screen, rasterised, and overlaid on the images before the classification procedure that outputs thematic map with the cover and land use categories (Figures 2 and 3). The results obtained from digitizing the shrimp farms on the Landsat 8 and QuickBird scene revealed a total of 9 shrimp farms covering almost 670.1 ha distributed close to the Coreaú river estuary. Although existing shrimp farms cover only 670.1 ha of land in the study area, the potential for expanding shrimp farms should

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take into consideration further political and environmental issues, since most of the suitable areas for shrimp farming are agricultural land.

Calculations showed that in the period 1960-2010, the area of mangrove increased from 3,413.1 ha to 3,843.3 ha, although the movement of dunes on the right bank of the Coreaú river have contributed to a slight reduction in mangrove (Figure 3). The increase of 430.2 ha in the extents of mangroves took place on soils previously occupied by non-mangrove land covers, mainly on the islands.

Assessment of water quality

During the studied period, the water temperature did not vary for samplings of influent and effluent and normal seasonal variation was observed (Table 3). Similarly, there were no significant differences in pH among influent and effluent water. Significant differences were observed for water salinity because of the difference in rainfall during the study period (2010 with 460 mm and 2011 with 1,241 mm). However, there was significant difference in salinity between samplings of influent and effluent. Furthermore, the values of dissolved oxygen, TAN, ammonia, nitrate, nitrite, total phosphorus and chlorophyll *a* were significantly higher in point of water discharge than on the pump station for the two years studied. However, BOD and turbidity only were significantly higher in point of water discharge than on the pump station during the year 2010.

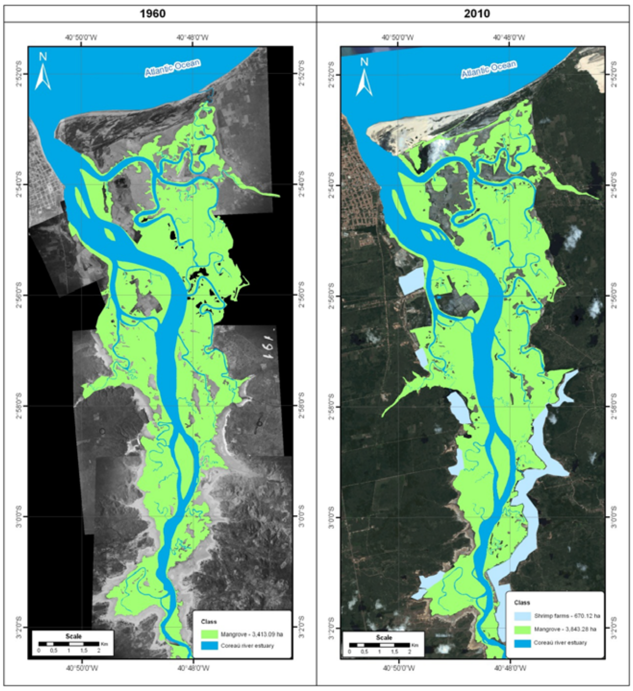

Figure 3: Thematic maps and area estimations of coastal wetland distribution in the Coreaú river estuary. Land cover categories obtained by digitisation and by means of a supervised classification for aerial photographs of 1960, Landsat Geocover of 1999-2000, CBERS of 2009-2010 and Google Earth images.

Discussion

In the Coreaú river estuary from 1998 until 2011, the shrimp culture activity grew from zero to 670.1 ha, which is 11.7% of the ponds in Ceará state. The rapid development of shrimp farming in this region is a similar phenomenon to that observed in other regions of the Ceará and in other states in Brazil [13,36,38]. Similarly, this growth has been observed in many tropical and sub-tropical countries because of the high economic returns [5,12,44,45].

Farming systems have gradually shifted from extensive traditional systems to improved extensive, semi-intensive and intensive production that are classified according to the pond size, water use, capital, labor, feed and chemicals used, and stocking densities [5]. In the Coreaú river estuary, semi-intensive shrimp culture utilizes pond enclosures than traditional farms (2.5-15.7 hectares), because this system provides significantly higher yields (5.9 ton/ha/yr), while intensive shrimp aquaculture practices are typified by high stocking densities in aerated ponds (1.3-2.1 hectares) and high production rates (8.1 ton/ha/yr).

Compared to other countries, intensive shrimp production system in the Coreaú river estuary has a relatively low stocking density (30-50 PL/m). Stocking density of comparative systems in Thailand, Taiwan, China or Mexico range between 50 and 100 PL/m [46,47].

Despite the expansion in the production area in recent years, diseases have not been a regular occurrence in the Coreaú river estuary shrimp farms in 2010-2012 [35,39]. Consequently, due to the absence of virus diseases farms have increased stocking density, production and yield. Although this industry has suffered a serious collapse due to disease outbreaks in period 2003-2009, the industry and Brazilian government are not using a SPF (specific pathogen-free) shrimp and Code of Conduct certifications [31,48]. Shrimp farms in the Coreaú

Parameter	Unit	2010		2011		Standard[1]
		Influent	Effluent	Influent	Effluent	
Temperature	°C	25.3 (25.1-25.9)	25.4 (24.3-26.9)	26.4 (20.9-29.9)	26.0 (21.9-30.1)	n.a.
Salinity	ppt	41.5 (39.0-44.0)	44.2 (30.0-52.0)	18.38 (0.0-32.5)	16.7 (0,0-35.0)	0.5-30.0
pH		7.7 (7.6-7.9)	8.0 (8.0-8.1)	6.9 (6.3-7.9)	7.0 (6.5-7.6)	6.0-9.0
DO	mg/L	4.7 (4.6-4.9)	8.2 (6.0-10.2) *	5.2 (2.6-7.4)	8.7 (5.0-15.4)*	>4.0
TAN	mg/L	0.55 (0.01-1.55)	2.55 (1.15-3.50) *	1.57 (0.01-1.31)	2.35 (0.95-3.25) *	≤ 0.40
Ammonia	mg/L	0.01 (0.0-0.01)	0.20 (0.04-0.47) *	0.02 (0.0-0.2)	0.14 (0.07-0.22) *	n.a.
Nitrate	mg/L	0.5 (0.5-0.6)	1.1 (1.0-1.5) *	0.3 (0.2-0.5)	0.9 (0.6-1.5) *	≤ 0.40
Nitrite	mg/L	0.01 (0.0-0.01)	0.04 (0.03-0.05) *	0.02 (0.0-0.05)	0.04 (0.1-0.07) *	≤ 0.07
Total phosphorus	mg/L	0.08 (0.06-0.09)	0.20 (0.11-0.40) *	0.08 (0.01-0.20)	0.20 (0.10-0.31) *	≤ 0.12
Chlorophyll *a*	µg/L	1.5 (1.0-2.0)	30.0 (15.0-45.0) *	1.8 (1.0-4.0)	15.2 (8.0-21.0) *	≤ 30.0
BOD	mg/L	1.2 (0.4-2.1)	8.4 (3.0-13.9) *	3.7 (1.4-6.3)	12.7 (4.7-25.0)	n.a.
Turbidity	NTU	1.5 (1.0-2.0)	37.5 (4.0-62.0) *	7.0 (4.0-13.0)	11.7 (6.0-18.0)	n.a.

Na: Not Available; [1]CONAMA (Brazilian National Environment Council) Resolution number 357 of March 17, 2005 (Brazilian water quality standard for industrial effluents discharged into brackish water). *Significant differences between Influent and effluent for each year studied.

Table 3: Characteristics of the influent and effluent from shrimp ponds in the Coreaú river estuary.

river estuary had not implemented biosecurity plans, best management practices (BPM) and the use of certified post-larvae despite of the diseases and other technical problems. Additionally, due to its high costs and lack of preparation of shrimp farmers, it is still estimated that most farms do not have their effluents treated.

In the Coreaú river estuary, shrimp farms operated all year round with various cycles per year. The objective is to obtain small shrimp sizes (100/120 and 80/100, count of head-on shrimp) which have a great demand and attractive prices in domestic market. The general trend in the region is to increase the stocking density (20-80 PL/m), due to high domestic prices. Unfortunately, due the absence of on-farm biosecurity protocols, these shrimp farms could be affected by diseases resulting in production inefficiencies and reduced profits.

To reduce the risk of crop failure and environmental pollution, farmers use a relatively adequate amount of feed, fertilizers and chemicals in shrimp farming. The application of probiotics in this region was relatively recent, but the interest in this protocol is increasing rapidly. Additionally, the use of pesticides, antibiotics and other toxic compounds has not been reported in shrimp farms of Coreaú river estuary.

This shrimp culture industry employs 565 people in the two municipalities (Camocim and Granja) where the Coreaú river estuary is inserted. Workers in the Coreaú river estuary generally have little education and must be trained for years to work effectively in a shrimp farm, while managers are normally brought in from urban centers and earn high salaries. The expansion of shrimp farms in the estuary of the River Coreaú is recent and this is attributed to potential high profits and the limited job opportunities. By contrast, shrimp farms in the estuaries of rivers Jaguaribe and Acaraú integrate more equipment and infrastructure and also create a larger number of direct and indirect jobs. Compared with the main producing area of the state of Ceará, the shrimp farms in the Coreaú river estuary generate only one quarter of the jobs compared to Jaguaribe river estuary [13]. It is recognized that this industry contributes significantly to rural employment as observed in other developing countries [9,49]. Community level benefits are seen as rural job creation, strengthening the local economy, poverty reduction and food security [24,49-51].

Unfortunately, it is not surprising that shrimp farm expansion has generated increasing criticism of its socio-environmental negative consequences, including the unemployment, marginalization of the rural poor, their increasing landlessness, breakdown of traditional livelihood support systems, increasing poverty, diminishing food security, and the transfer of land and wealth to local and national élites [3,40]. However, evidence for these cases is not presented objectively by authors of these criticisms. On the contrary, shrimp farms in the Coreaú river estuary are responsible for stimulating the local economy and improving the welfare of traditional communities.

A large number of earth observing satellites has been orbited, and is providing frequent imageries of its surface. From images generated by these satellites, several studies can provide useful information for sustainable management of shrimp farms [52-55].

Land evaluation using GIS techniques estimates that a total of 670.1 hectares of shrimp farm facilities in the Coreaú river estuary were established mainly on saltmarshes and/or carnaubal palm forests and/or agriculture areas (Figure 2). These land covers are consist up of flat land and soils with fine textures and low infiltration rates that make them ideal for building shrimp ponds. Nevertheless, mangrove forest area increases were observed during recent years. Calculations showed that in 1960 nearly 3,413.09 ha of mangroves were observed, reaching about 3,843.28 ha by 2010 (Figure 3), resulting in an annual average rate of mangrove area increase of 2.0% yr^{-1}. Additionally, the results indicate that no shrimp farm was constructed on mangrove areas.

Shrimp farm development in several countries is recognized as one of main factors contributing to mangrove deforestation. In Brazil, the growth of shrimp farming has generated false criticism of its environmental consequences, including mangrove conversion and expropriation [40]. For example, due to lack of evidence, the author tries to relate the growth of mangrove areas (980 to 1,020 ha) with abandoned shrimp farms, despite an expansion from 295 to 2,468 ha, in the period 1988-2011. However, in the study area (Jaguaribe river estuary), there are no abandoned shrimp farms [13].

Although the pollution potential of shrimp pond effluents is minimal compared to domestic or industrial waste water [56], problems arise because of the large volumes of water discharged from intensive farms and compounded due to the high concentration of farm units in areas with limited water supplies and inadequate flushing [53]. Despite their importance, relatively little is known about the pollution potential of shrimp pond effluents in Brazil.

Water quality values obtained from the current study were within the acceptable range for *Penaeus vannamei* culture. Additionally, physical, chemical and biological values of water quality during the monitoring period were maintained within the Brazilian water quality standard for industrial effluents discharged into brackish water except for TAN (convert to ammonia), nitrate, nitrite, total phosphorus and chlorophyll *a*. However, Brazilian water quality standards for industrial effluents discharged are more restrictive than BAP standards (Global Aquaculture Alliances Best Aquaculture Practices Standards). Brazilian water quality standards for TAN and total phosphorus are ≤ 0.4 mg/L and ≤ 0.12 mg/L, respectively, while for BAP standards are ≤ 5.0 mg/L and ≤ 0.5 mg/L, respectively. Water quality monitoring did not indicate significant impacts of pond effluents in various estuaries worldwide [5,19,57-61]. Additionally, several researches have demonstrated effluent water from shrimp ponds typically contains elevated concentrations of dissolved nutrients compared to influent water [5,19,59,61].

On the other hand, the values of each environmental parameter remained stable during the period 2010-2011 indicating the capacity of the estuary to recycle nutrients. For example, TAN levels measured in the influent did not differ significantly during the years 2010 (mean 0.55 mg/L, ranging between 0.01–1.55 mg/L) and 2011 (mean 0.57 mg/L, ranging between 0.01–1.31 mg/L). The mangrove estuaries have some capacity to tolerate periodic inputs of effluent from intensive shrimp ponds [58]. The authors suggest that the effluent can be dissipated by tides and assimilated and/or mineralized by the estuarine. Unfortunately, some studies correlate shrimp farms to estuarine pollution, despite the cumulative impact of various anthropogenic sources that result in discharge of domestic, agricultural and industrial wastes into coastal waters [61].

Conclusions

This paper has assessed the technical, economics, social and environmental aspects of shrimp farming in the Coreaú river estuary, Ceará, Brazil. These aspects are very important to develop this industry in a sustainable way. Additionally, the sustainability of the shrimp farming relies of complete policies and regulations, a healthy environment and technological advance. In the Coreaú river estuary, this industry is dominated by semi-intensive and intensive culture systems with an average production of 5.9 to 8.1 ton ha^{-1} y^{-1}. This productivity is gained by the use of hatchery-raised post-larvae, fertilizers, supplementary feeding and a limited degree of mechanical water management. In this estuary, shrimp farming industry has promoted in terms of the possibility of increasing rural employment, strengthening local economy, poverty reduction and food security. Due to the international market failure and high production costs, most of the farmed shrimp produced in Brazil have been sold within the country in the past few years. Finally, despite the large number of literatures reported negative effects of shrimp farming on the environment, results presented indicate that no shrimp farm was constructed on mangrove areas or cause significant pollution estuary waters. However, it is important to say that the environmental monitoring period was relatively short and further studies should monitor environmental variables during longer periods.

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