Chapter 6

ENVIRONMENTAL IMPACTS

The development of shrimp farming in the coastal areas of India attracts more attention nowadays. The high rate of economic return of shrimp farming definitely indicates towards development but the unplanned and unregulated way of shrimp culture also introduces some kind of complicity impact. In this present chapter, environmental impacts of shrimp farming are also identified and discussed along with socio-economic impacts. Soil and water sample analysis, Questionnaire Checklist, Cost-return Analysis, and Leopold Matrix are used for this study.

6.1 Introduction

India is an extraordinarily rich country on the basis of land, water, climate and human resource. But the efficient utilization as well as, sustainable use of these resources is extremely poor. These highly valuable resources are found in really poor condition in the coastal areas. In a country like India where there is a need for new employment opportunities, foreign exchange earnings and economic growth, at the same time conservation of natural resources and maintaining fine environmental conditions is highly required.

The development of shrimp farming in the coastal areas of India attracts more attention nowadays. The high rate of economic return of shrimp farming definitely indicates towards development but the unplanned and unregulated way of shrimp culture also introduces some kind of complicity impact. The success of a business is dependent on the market demand of its product and its adequate prices. Trade policy promotion, high demand for shrimps in the international market, the suitable environment of shrimp culture in coastal areas has made India a highly productive country for shrimp culture. Shrimp is a luxury food and its high demand in the international market motivates people towards shrimp culture (Tobey et al., 1998). Shrimp is an important source of foreign exchange earnings and contributor to huge employment opportunities. In the year 2013 total of 23814.73 crores (3726.36 million dollars) shrimps has been exported from India (MPEDA, 2017). This high export of shrimp has a huge contribution to our national income. The labours which are related to shrimp farming gain high wages compared to the labours of other fields. According to a global study it is found that the labours of shrimp farms earn 1.5 to 3 times compared to other labours (Anon, 2002). Because of its high earning opportunity, the farmers of South-East Asian countries such as Bangladesh, India, Thailand are using their land for shrimp culture these days (Barraclough and Finger-Stich, 1996; Kumaran et al., 2003). Also because of shrimp farming more additional employment opportunities have opened up for the locals. Some opportunities are for farm technician, workers for processing unit, marketing, ice factory, sales, feed industry, transportation etc.

Shrimp farming is noticed in the coastal areas of our country i.e. in Andhra Pradesh, West Bengal, Odisha, Tamil Nadu, Kerala, Maharashtra. The higher earnings from shrimp farming are highly motivating the locals of coastal areas towards shrimp culture. Presently shrimp culture in the coastal area is an important economic activity. In the case of poverty alteration, employment creation, community development, foreign exchange earnings and infrastructure development shrimp farming has a great impact (Huntington, 2003; Masum, 2008). The net profit earned from shrimp farming is much higher than rice production (Bhattacharya and Ninan, 2009; Reddy et al., 2004).

The most important factor behind government promoting shrimp farming is that it creates huge employment opportunities. In Asian countries, the number of labours required per unit area of shrimp farming is much more compared to the labours required per unit area of rice farming (Hanbrey, 1993). Another positive side of shrimp farming is infrastructure development such as road construction, electricity distribution, water facility etc. With these positive effects of shrimp culture, some adverse impacts also seek attention for its sustainable development. People have already understood its high-profit earnings and hence moving to shrimp culture from doing traditional agriculture. The farmers who have good investment capabilities motivates the poor farmers by paying higher profit compared to paddy farming and hence also converted their agriculture land to shrimp ponds (NACA, 2000). The coastal states and union territories of India such as in Tamil Nadu, Andhra Pradesh, Odisha and Goa every year a huge area of agriculture land is converted to shrimp farming area (Aquaculture Authority of India, 2002).

The lifespan of the shrimp ponds lies between 5-10 years in case of intensive shrimp culture. It is due to self-pollution and infestation (Primavera, 1997). In these regards, the shrimp farmers avoid or leave those ponds and look for new better options for shrimp culture in a new agriculture land area (Csavas, 1994). When these abandoned ponds turn again into agriculture land, the natural productivity of the land decreases badly. According to the report of Rosenberry, 1995, globally total 1,147, 300 ha of abandoned ponds are available out of which 847,000 ha are present only in Asia.

There are many adverse effects of shrimp culture that has been reported, but the most badly affected area is agriculture. The use of direct sea water in shrimp farming has increased the salinization of land, surface and ground water. Hence the major crop of costal area rice is badly affected and a huge reduction in productivity is noticed. Various illegal activities involved in shrimp farming such as use of big machinery, making small canals digging the nearby area, use of chemicals for more shrimp productivity etc. have affected the nearby river, stream, canal and the surrounding environmental conditions. The saline water follows through this affected area increases the salinization of close agriculture land and hence it affects agriculture productivity (Anon, 1993). To increase the production of semi-intensive and intensive shrimp farming artificial feed, chemicals and antibiotics such as soil water treatment compound, plankton growth inducer (fertilizer and mineral), algaecides and feed additives are used. Right after the shrimp farming period, this chemically polluted water is released to nearest creek, river and stream which affects human health and pollutes the environment (Saitanu et al., 1994).

In South-East Asia shrimp farming is growing to a large extent using huge amount of saline water. To balance this salinity of water and for the nearby rice field areas, ground water has been used continuously. Hence the level of ground water goes down and it creates empty aquifer. Now because of seepage and leakage saline water flows to this empty aquifer and it increases the salinity of ground water (Patil and Krishnan, 1998).

Coastal wetland is one of the most suitable environmental conditions for shrimp farming. Hence for better shrimp productivity every year a huge mangrove area is destroyed. The conditions of flora and fauna surrounded to these mangrove forests are also going worse and decreasing in a huge extent. Globally 30% to 70% of mangrove forests are lost only because of shrimp farming (Barbier and Cox, 2004).

It is difficult to interpret the specific data and information on shrimp culture in India and its simultaneous environmental impacts. It is because of lack of proper data regarding this area. Most of the information is collected from experiential learning, also from some interviews, field investigation of some particular areas and from some comparatively reliable secondary sources. Using magnitude, intensity or force of impacts and importance or significance scales of impacts generally the assessment of impacts are evaluated. For impact identification and assessment Questionnaire Checklist and Leopold Matrix are very popular scientific methods in term of the physical, natural and social environment impacts, which are actually the direct and indirect changes and are generated by some proposed actions (Maya and Fono, 1997). The importance of impacts can also be divided in reversibility, whether or not an impact is susceptible to mitigation, recoverability, the capacity of an impacted environmental resource to get back to original conditions and duration of an impact. The Leopold Matrix has a significant advantage over the other impact assessment methods due to its matrix used as a checklist or reminder (Leopold et al., 1971). The scale of importance in the Leopold Matrix ranges from 1 to 10, where the importance increases with the increasing value with 1 being least important and 10 being the most important. Further plus (+) or minus (-) signs can be used to show the impact being beneficial or adverse.

6.2 Materials and Methods

An initial scoping of impacts identifies those impacts thought to be potentially significant to the environment and the society of the area. It determines the range of issues to be analyzed on priority basis. There exist analytical numerous methods for impact identifications and assessment, among these soil and water quality testing, Cost-return Analysis, Questionnaire Checklist and Leopold Matrix are used for this study.

6.2.1 Soil and water sample collection and analysis

To analyze the soil and water quality, samples of soil and water are collected from shrimp farming sites of five different study blocks. For better result, the soil samples are collected right after completion of the shrimp farming period from the shrimp ponds and adjoining agriculture land and water samples are collected from the shrimp ponds, nearby river/ stream/ canal and tube wells during the active shrimp farming period. For this purpose mainly pH for both soil and water is analyzed. For both the year i.e for

2012 and 2016 total 120 number of soil sample (120/year) and total 45 numbers (45/year) of water samples are tested. The location of the sampling sites is recorded by the GPS. The details of the sampling procedure are discussed in section 4.2.2.1.

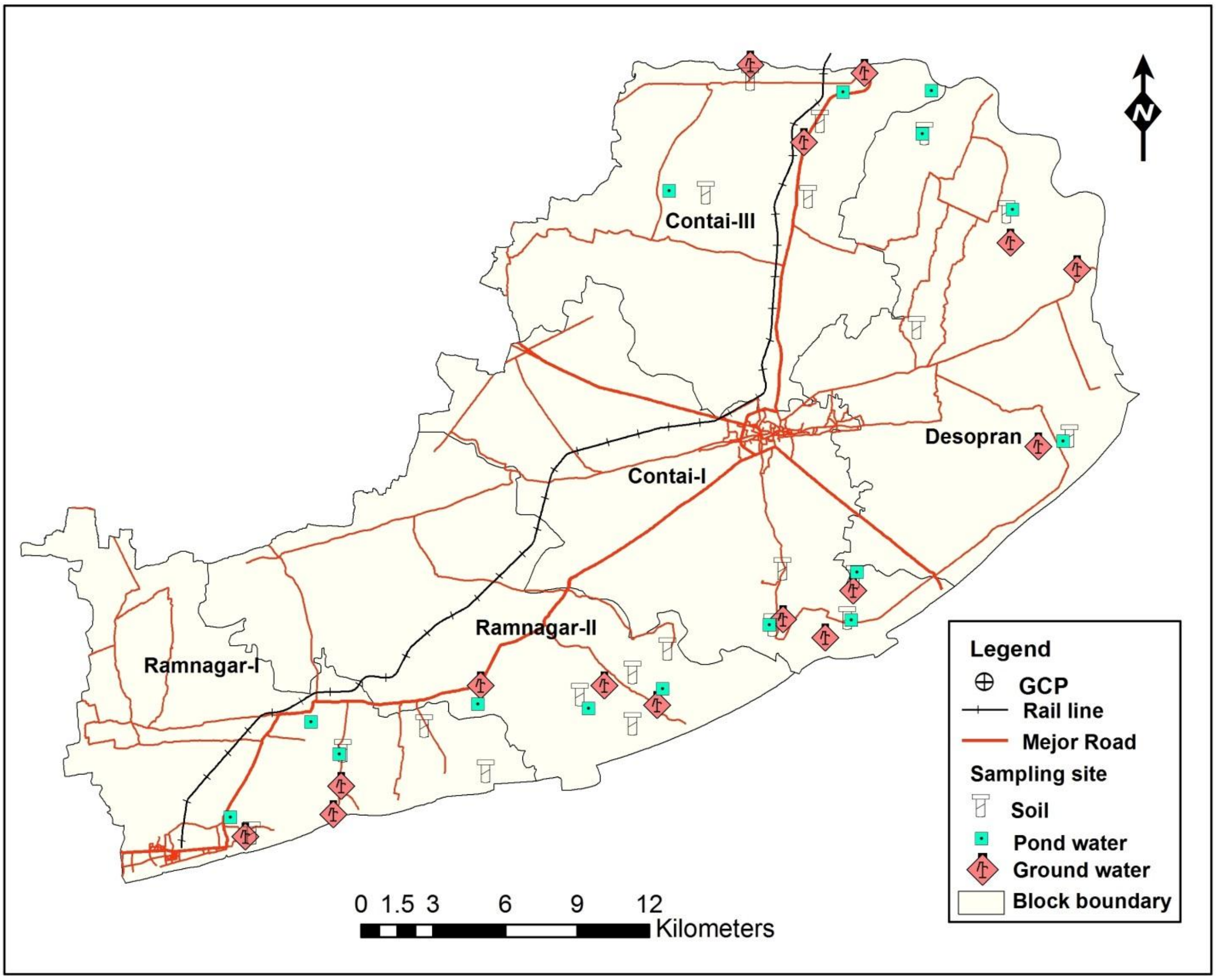

Figure 6.1 Soil and water sampling locations in the study area

6.2.2 Cost-return analysis

Cost-return analysis is a process by which the economic viability of shrimp culture could be assessed. In this study, all the investment for farming is considered as 'cost' and the profit earned is referred to as 'return'. Based on the culture to get total cost value with respect to profit a balance sheet is made (Appendix-C). In this present study, the cost return of traditional agriculture (paddy) and shrimp culture are compared to find out which one would be more beneficial for the local community and socio-economic condition of the study area. The data for this calculation is collected from different shrimp farmers (high scale farmers and low scale farmers, traditional farmer and scientific farmer). In a similar way, the data has been collected for agricultural land (paddy field) too. In both the cases, the cost return is calculated on one acre of area. Data has been collected from 50 shrimp farmers and 30 rice farmers through primary survey.

6.2.3 Checklist for identification of key impacts

The method of Questionnaire Checklist is followed for the identification of key impacts (Glasson et al. 1999). The door to door household survey in fifteen (15) Mouzas (Villages) surrounding the shrimp farming sites has been done. A set of questions, related to the impact of the shrimp farming on the society and economic condition of the local people were set to be answered. Some of the questions also concern indirect impacts and possible migration measures. Few of them are associated with a scale for classification of the estimated impacts, ranging between highly adverse (-10) and highly beneficial (+10). It was found that the impact of the farming is prominent on almost twenty-one (21) human environmental elements of the region and thirteen (13) project actions (Table 6.1) are primarily responsible for these impacts. Not only questionnaire survey but also the analysis of satellite images and field investigation helped to find out the prime impacts. The first one designates impact magnitude, from +10 (very positive) to -10 (very negative); another denotes significance of the impact, from 10 (very significant) to 1 (insignificant). The products of these two values were summed up once row-wise, and then column-wise. Row total represents the impact of all project actions on individual environmental components, whereas column total represents the impact of individual project action overall environmental components.

6.2.4 Leopold Matrix for assessment of impact magnitude

The major impacts of the study can be obtained from Questionnaire and field survey mentioned earlier. Once the key impacts are shortlisted from Questionnaire Checklist and field investigation; Leopold Matrix of Leopold et al. (1971) is used to assess the magnitude of impacts of individual project actions on individual human environmental elements. For this assessment, the Leopold Matrix itself consists horizontal list of hundred (100) project actions (like River control and flow modification, Canalization, Cut and fill etc.) and vertical list of eighty-eight (88) environmental components (Like Erosion, Deposition, Salinization of water resources, lifestyle etc.). Among these, thirteen (13) project actions and twenty-one (21) human environmental elements were selected (Table 6.1) for this study, which is exactly identical with the action and elements identified from the Questionnaire Checklist and field investigation. Number (LM-No) of each project action and environmental components (e.g. A/d/3, B/1/c) are kept intact as in the original "Leopold Matrix". Now, after few modifications of Leopold Matrix, 273 possible interactions between these project actions and environmental components are recorded in the matrix.

Table 6.1 Selected project action and environmental elements from Leopold Matrix

Sl. No.	**LM-No.**	**Project Action**	
1	A/d/1	Modification of regime	Agriculture land to shrimp pond
2	A/d/2		River/stream/canal to shrimp pond
3	A/d/3		Scrub land to shrimp pond
4	A/d/4		Vegetation cover to shrimp pond
5	A/g/1		Brackish water flow modification
6	B/b/1	Land transformation and construction	Processing unit, Ice Factory, ware house
7	B/e		Road and trails
8	B/l/1		Inlet/outlet canal and drainage
9	B/r/1		Cut new tanks
10	B/r/2		Fill agriculture land
11	D/a	Processing	Shrimp farming
12	H/e	Waste emplacement and treatment	Junk disposal
13	J/b	Accident	Spill/leaks
Sl. No	LM-No	Environmental Elements	
1.	A/1/c	Physical and chemical characteristics	Soil
2.	A/1/d		Landform
3.	A/2/a		Surface water
4.	A/2/c		Under ground water
5.	A/3/a		Atmosphere(gases, particles)
6.	A/3/c		Temperature
7.	A/4/b		Erosion
8.	A/4/c		Deposition/sedimentation
9.	B/1/a	Biological condition	Tree
10.	B/1/b		Shrub land
11.	B/2/c		Fish
12.	B/2/g		Endangered species
13.	C/1/e	Cultural factors	Agriculture
14.	C/4/a		Life style
15.	C/4/b		Health and safety
16.	C/4/c		Employment
17.	C/4/e		Social value
18.	C/5/b		Transportation network
19.	C/5/d		Waste disposal
20.	D/a	Ecological relationship	Salinization of water resources
21.	D/e		Salinization of surficial material

There are two main factors available for environmental impact analysis. First is the "magnitude" of impact on a specific sector and other is the "importance". "Magnitude" is the sense of degree or scale and the "importance" is the significance of proposed action on the specific importance of impact. Both "magnitude" and "importance" can be analyzed together with the help of Leopold Matrix and this method is very convenient for environmental impact assessment. The Leopold Matrix has a significant advantage over the other impact assessment methods due to its matrix used as a checklist or reminder (Leopold et al., 1971). The scale of importance in the Leopold Matrix ranges from 1 to 10, where the importance increases with the increasing value with 1 being least important and 10 being the most important. Further to show the impact is beneficial or adverse, plus (+) or minus (-) signs can be used to indicate positive and negative impacts. The scale of magnitude can also be considered on a range of 1 to 10.

In each interacting cell, two numbers are recorded, column total represents the impact of individual project action on all environmental components. For overall impact evolution, whole study area is block-wise divided. The summed up values off all impacts are represented in Table 6.10.

The following example will give the idea of the assessment done based on the Leopold Matrix: It is evident that increase of soil salinity due to shrimp farming is a negative impact of shrimp farming. Now, the maximum numbers of shrimp farms can be found in Ramnagar-I where the coastal wetland or saltpan was already present. In other words, the soil salinity was naturally high in those agricultural lands in which shrimp farming is being done. So, in this block very little amount of soil salinity has increased due to shrimp farming. So, the negative impact (-) of shrimp farming is less compared to other areas. Keeping that in mind, on a scale of importance from 1 to 10, it can be given (-) 5. Previously it has been mentioned that in this block the shrimp farming is limited only in the coastal area. So the spatial distribution of impact is low comparing to the other blocks. Hence, the magnitude impact (again on a scale from 1 to 10) can be set to 4. So the total impact on soil due to shrimp farming is $(-5\times4)=-20$ (combination of both). Likewise due to shrimp farming job opportunity has been created for many people. It is obviously a positive impact (+). The score of importance of this positive impact is set to (+) 6. Again, these opportunities are for 6 to 8 months. So this impact can be considered to be long term, hence the impact of magnitude is set to 6. So the combined total impact on employment generation is (+6×6)= 36. Thus the positive or negative impacts on A. Physical and chemical characteristics, B. Biological conditions, C. Cultural factors and D. Ecological relationships due to the block wise shrimp farming have been brought out following the Leopold Matrix. The impact value (importance and magnitude) has been drawn here depending upon three major factors. Those are:

1. Which are impacted (what are having the impact)
2. Sources of impact
3. Significance of impact

6.3 Results

Due to the continuous growth of shrimp farming in the study area, a drastic change has been noticed in the economic sector of that area. Many job opportunities have been created and new opportunities have come up. People started investing in shrimp farming or other fields related to shrimp farming which has enhanced the economic growth of the area. But on the other hand shrimp farming has also some noticeable and unavoidable negative impacts which create a great threat towards the sustainable development of shrimp culture. The positive and negative impacts of shrimp farming are elaborately described in this discussion.

6.3.1 Impacts on physical environment

Apart from positive economic growth, shrimp farming has also some negative impacts on the physical environment. But for sustainable development, it is necessary to create a balance between the economic growths and maintain environment condition, which is actually not happening in the present study area. The major impacts of shrimp farming on physical environment are discussed in this section.

6.3.1.1 Changes recognized on waterbodies

The Land use and land cover classes collected through multi-temporal satellite images (for year 2008 and 2016) are analyzed block-wise and it is seen that the total water body of the study area is increasing continuously. The detailed statistics of the total waterbodies are shown in Figure 6.2. Now by considering class wise distribution of total water-bodies, increases in brackish water tanks/ponds are shown in Figure 6.3.

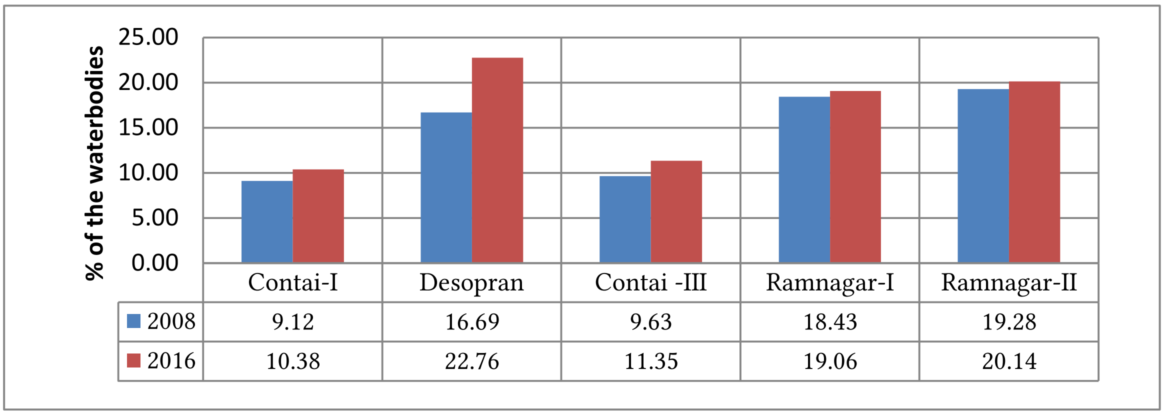

Figure 6.2 Bar graph representing temporal variation of block wise total waterbodies for the period of 2008 to 2016

Desopran block has experienced the highest change (increase). In 2008, the area covered by total waterbodies are 3067.49 ha i.e 16.69 % of total block area, which increased to 4184.11 ha (22.76%) in 2016. In the case of brackish water tanks/ponds, the coverage of the area in the year 2008 was 917.21 ha which was 30% of the total waterbodies. This value increased to 1968.07 ha i.e 47% in the year 2016. If we see carefully in 8 years 1050.86 ha of brackish water tanks/ponds has increased. Similarly, the other blocks have also experienced an increase in total water bodies and also an increase in brackish water tanks/ponds. This increase in water bodies indicates the aquaculture development of the study area and also the increase in shrimp farming of those areas. Because of these the land resources of the study area is decreased and which in turn dis-balances the natural bio-diversity.

Table 6.2 Temporal variation of block wise distribution of different classes of waterbodies for the period of 2008 to 2016

Blocks	**Year**	**Area (ha) of the different classes of Waterbodies**						**Total Area (ha)**
		Bwtp	**Nj**	**W**	**S**	**Fwtp**	**Wl**	
Contai-I	**2008**	286.82	65.32	363.65	163.03	681.45	1.18	**1561.45**
	2016	451.70	64.31	355.08	163.03	743.03	1.18	**1778.33**
Desopran	**2008**	917.21	20.32	627.51	482.07	1020.38	0.00	**3067.50**
	2016	1968.07	20.69	627.40	482.09	1085.86	0.00	**4184.11**
Contai–III	**2008**	199.64	58.56	382.18	0.00	915.52	2.41	**1558.31**
	2016	472.93	58.66	382.55	0.00	919.41	2.41	**1835.95**
Ramnagar-I	**2008**	932.91	87.68	385.48	608.51	554.79	3.96	**2573.33**
	2016	1009.15	85.63	385.64	608.54	568.74	3.97	**2661.68**
Ramnagar-II	**2008**	1882.94	63.09	571.02	130.43	466.16	0.99	**3114.63**
	2016	2002.73	59.72	554.88	130.44	504.56	0.99	**3253.32**

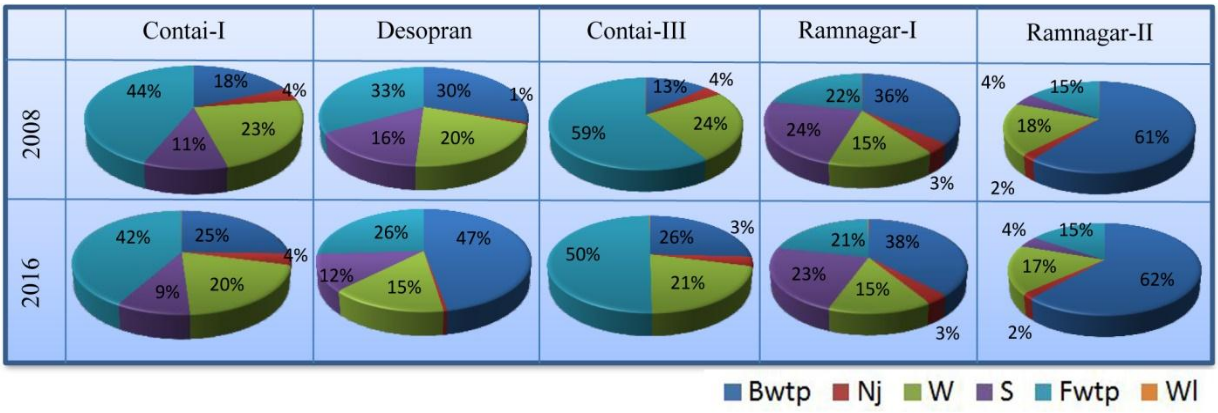

Figure 6.3 Pie diagram representing temporal variation of block wise distribution of different classes of waterbodies

6.3.1.2 Soil quality degradation

The effect of shrimp farming on agriculture land can easily be determined by analyzing the values of soil pH and salinity of the soil. A distance of 10 meters in radius from the shrimp farms has a very high value of soil salinity and pH. The values of these two factors are always varying and as per the data collected for the study area from year 2012 to 2016, it is seen that the pH level and the salinity has increased drastically. It is visible clearly in table (Table 6.3). The soil properties of the nearby agriculture land are badly affected due to the poor management of shrimp farms, seepage, leakage etc. Hence the agriculture productivity of those areas is also affected. The main reason behind this is that the increased level of soil pH and salinity affects the soil nutrients (eg. Organic C, N, K, and P) which are the key factor of productivity of any agriculture land. Approximately 1185 ha of agriculture land of the study area is affected if we consider 10 meter radius as an affected zone. 711 ha in Desopran block, 270 ha in Contai-III, 75 ha land of Ramnagar-II and 64 ha of agriculture land of both Contai-I and Ramnagar-I block is affected by shrimp farming. The spatial distribution of blockwise affected agricultural land is shown in Figure 6.6 and Figure 6.14.

Among all blocks, Desopran block and the Contai-III block are the most affected. The high and low range of soil salinity has gone through a noticeable change in these two blocks. These blocks are little far from the sea and the agriculture productivity was really good in that area, but now with the changes in soil properties, this productivity is decreasing. From the current analysis, it is clear that up to 10 meter distance from the brackish water tanks/ponds the soil salinity and pH are more because of seepage, leakage of saline water from the shrimp ponds. Because of this soil salinity and pH are changing gradually in the adjacent area. Moreover, the paddy fields are also badly affected by saline water through drainage process when the tank owners fill their tanks from tidal river and canals. Soil salinity and pH damaged the adjacent paddy field when the owners drain out the existing water after shrimp culture.

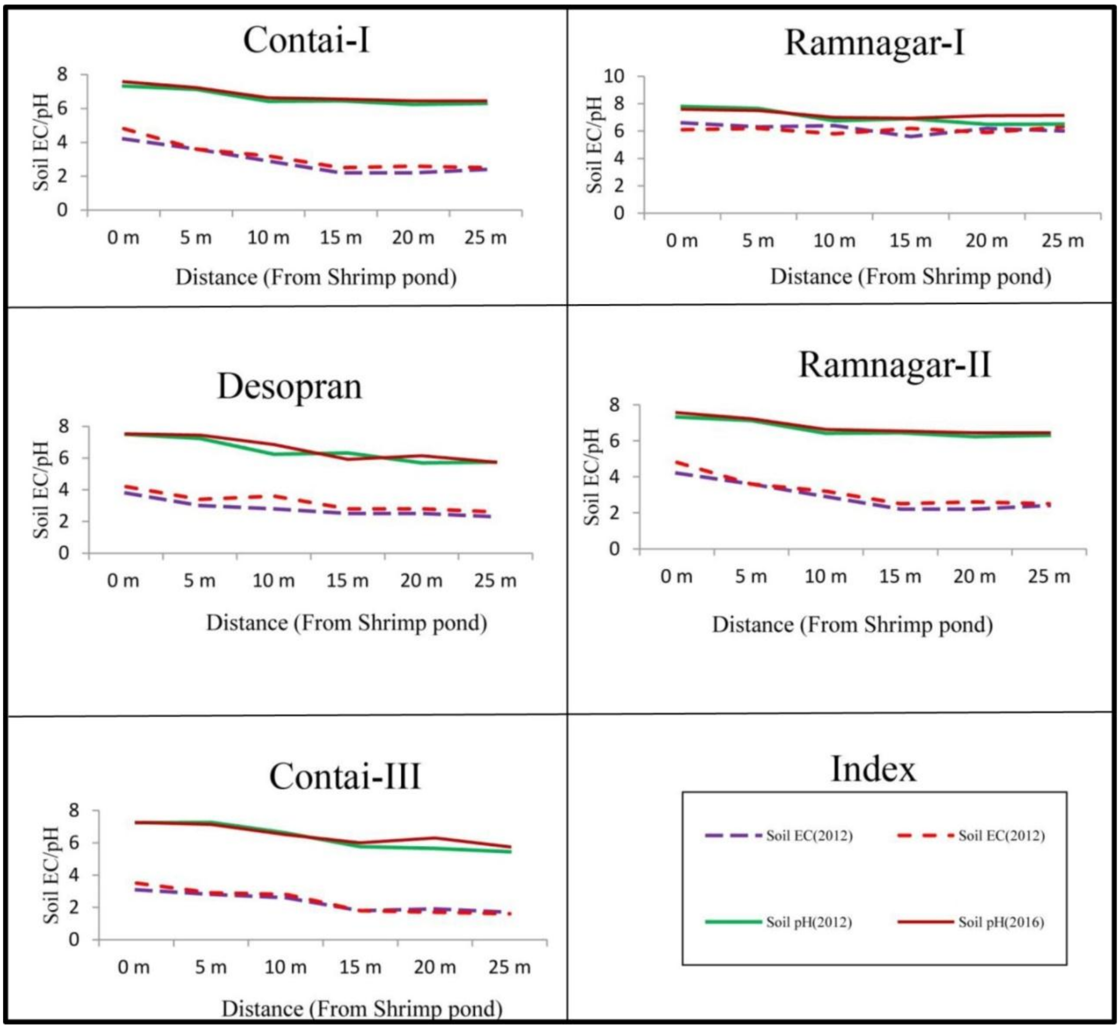

Figure 6.4 Soil pH and salinity (EC) of the nearby agricultural land with respect to the distance from shrimp pond for the year 2012 & 2016

Table 6.3 Block wise soil salinity and pH in agricultural field nearer to shrimp farm

Block Name	Distance (From shrimp pond)	Soil EC (dS/m)				Soil pH			
		2012		2016		2012		2016	
		Range	Average	Range	Average	Range	Average	Range	Average
Ramnagar-I	0 m (Inside Pond)	3-5-8	6.6	3-7.3	6.1	7.52-8.7	7.8	7-8.32	7.6
	5 m	3-7.9	6.3	3.6-7.5	6.2	7.2-8.1	7.64	6.42-8.22	7.5
	10 m	5.5-7.4	6.4	5-7.7	5.8	6.23-7.6	6.76	6.5-7.65	7
	15 m	4.5-7.2	5.6	5.3-7.6	6.2	6-7.80	6.91	5.75-7.76	6.94
	20 m	4.3-7.2	6.2	4.9-7.8	5.9	5.5-7.35	6.5	6.34-8.31	7.12
	25 m	5.5-6.8	6	5.1-7.4	6.3	5.42-7.52	6.52	6.12-7.8	7.14
Ramnagar-II	0 m (Inside Pond)	5.1-7.8	6.3	5.1-8	6.5	5.8-7.76	6.9	6.12-7.54	7.12
	5 m	5.3-8	6.5	5-7.3	6.3	6.12-7.24	6.76	6.64-7.81	7.32
	10 m	5.5-7.6	6.4	4.9-6.8	6.2	6.24-8.13	6.77	6.54-7.88	6.86
	15 m	4.3-7.8	5.6	5.2-7.5	6.1	5.68-7.43	6.56	6-7.28	6.54
	20 m	5.2-7.3	6	4.9-7	5.6	5.24-7.56	6.5	5.78-7.65	6.66
	25 m	4.6-7.9	6.2	4.5-7.1	5.8	6.17-7.88	6.62	5.68-7.59	6.58
Contai-I	0 m (Inside Pond)	3.2-5.1	4.2	3.4-6	4.8	6.43-7.80	7.32	6.77-7.78	7.57
	5 m	2.5-4.7	3.6	2.2-5.1	3.6	6.33-8	7.12	6.30-7.75	7.23
	10 m	2.2-3.8	2.9	2-4.4	3.2	6.12-6.88	6.42	6.32-7.15	6.63
	15 m	1.4-3.2	2.2	1.7-4	2.5	5.65-6.90	6.45	6.10-6.90	6.55
	20 m	1.2-3.5	2.2	1.7-3.1	2.6	5.90-6.66	6.24	5.55-6.85	6.44
	25 m	1.7-4.2	2.4	1.8-3.5	2.5	5.85-6.55	6.3	6.00-6.55	6.45
Desopran	0 m (Inside Pond)	2.8-4.6	3.8	3.2-5.3	4.2	6.00-8	7.5	6.30-7.75	7.54
	5 m	2.2-3.8	3	2-3.9	3.4	6.2-7.65	7.25	5.96-8.12	7.45
	10 m	1.8-3.4	2.8	1.5-5	3.6	5.75-6.44	6.24	6.30-7.48	6.86
	15 m	1.5-4.2	2.5	1.9-3.8	2.8	6.00-6.54	6.32	5.55-6.94	5.93
	20 m	1.2-3.4	2.5	2-4.1	2.8	5.54-6.42	5.7	6.0-6.75	6.15
	25 m	1.2-3	2.3	2.3-3	2.6	5-7.25	5.75	5.45-6.75	5.75
Contai-III	0 m (Inside Pond)	2.5-4.2	3.1	2.8-5	3.5	5.97-7.83	7.25	6.55-7.96	7.27
	5 m	1.8-3.2	2.8	2-3.5	2.9	5.54-7.88	7.26	6.32-7.75	7.13
	10 m	1.5-3	2.6	2.2-3.2	2.8	6.10-7.22	6.62	6.00-6.85	6.5
	15 m	0.9-2.5	1.8	1.2-2.5	1.8	5.45-6.28	5.76	4.98-7	6
	20 m	0.8-2.8	1.9	1.2-2.3	1.7	5.48-6.75	5.65	4.90-6.55	6.3
	25 m	1-3.4	1.7	1.5-2.3	1.8	5.30-6.15	5.45	5.30-6.70	5.75

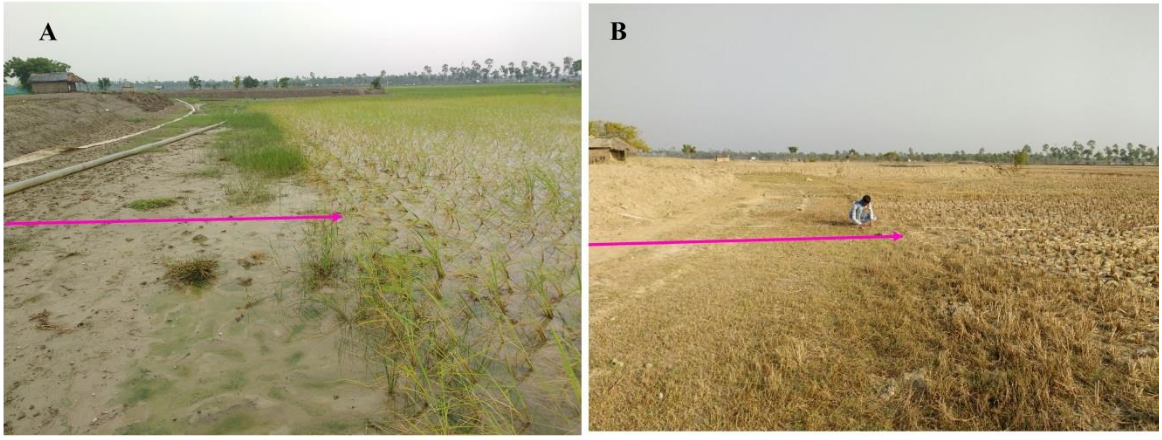

Figure 6.5 The images show affects of shrimp culture in the nearby paddy field. The paddy field in Fig. A is of after transplant and Fig. B is of after harvesting. The arrow shows the distance of nearly five meters. In both cases, it can be seen in the picture that the land has become infertile which is due to increased salinity because of the nearby shrimp ponds.

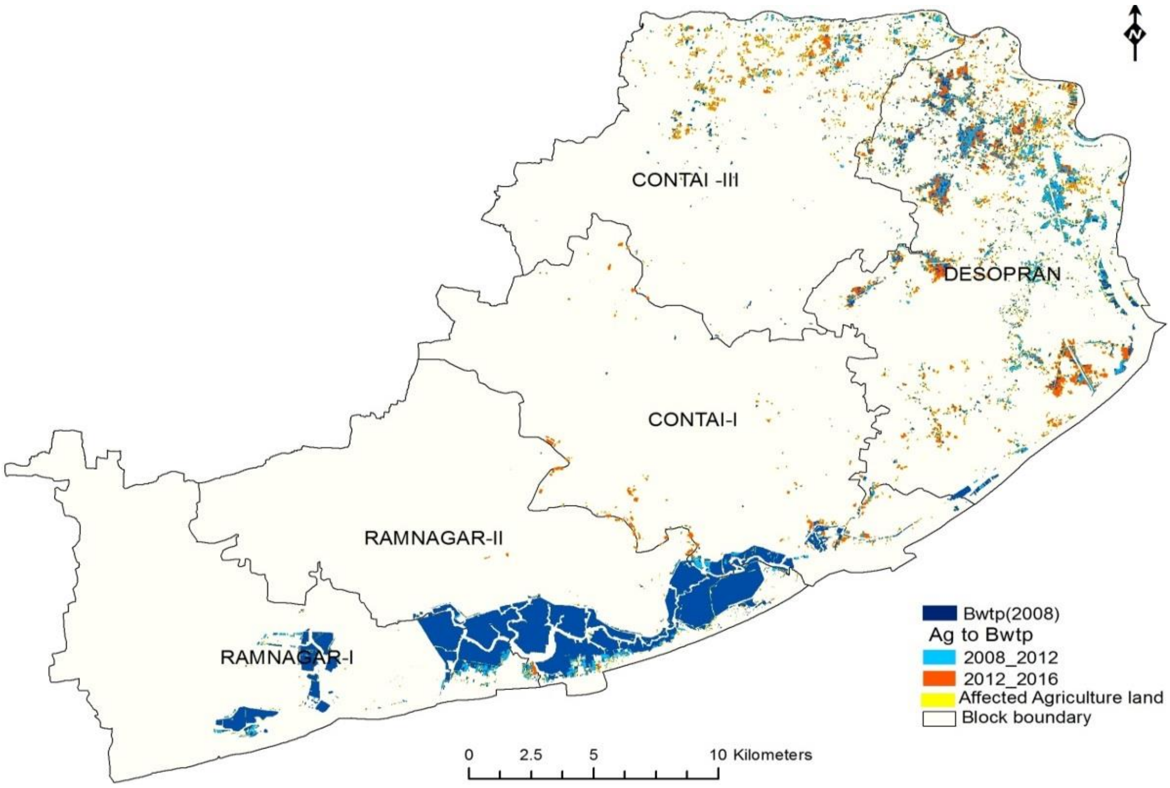

Figure 6.6 Map representing change in Land use with respect to conversion of agricultural land to brackish water tanks/ponds for the period of 2008 to 2016 and also showing the affected agricultural lands because of increase in soil salinity.

6.3.1.3 Water quality deterioration

While considering physical environmental condition, water quality plays an important role. Based on the quality of water the agriculture and shrimp culture of a particular area gets influenced. Hence in this research tests are performed to check the quality of water and analyzed its importance and effect on both traditional agriculture and shrimp farming. During shrimp culture period i.e from June to September the soil salinity and pH of water has been tested on field visit. Salinity is tested by a refractometer and soil pH is tested with the help of a pH meter. These tests are done in shrimp ponds, nearby water supply sources of shrimp ponds i.e nearby river/stream/canals and also from tube-wells which are close to the shrimp ponds. The average salinity of shrimp ponds in the year 2012 is 11.5 ppt (range 9-15 ppt), pH is 8.7 (range 8.3-9.4) and average salinity of nearby river/stream/canal is detected as 11.25 ppt (range 8-15 ppt), pH is 8.5 (range 8-9.7); pH of tube well is 7.32 range (7.17-7.36) and salinity of tube well is detected below 1 ppt. In 2012 out of 15 tube-wells salinity is detected in only 3. Similarly in year 2016, the data are collected. Average shrimp ponds salinity 10.75 ppt (range 8-13), pH is 8.45 (7.8-9.87); average nearby river/stream /canal salinity 11 ppt (range 9-14), pH is 8.5 (range 8-9.7) and for tube-well salinity is below 1 (approx. 0.7 ppt) and pH is 7.29 (range 7.15-7.38). Hence it is seen that there's no such difference between the collected data of water salinity and in case of pH the value of shrimp ponds is slightly higher compared to nearby river/stream/canal. In case of tube well the salinity is seen only in 4 tube wells out of 15 tube well samples. Even the face of salinity lying below 1 ppt, indicates the presence of salt. Local people of the study area have also informed that they feel the tube well water saltier than it was before.

Use of chemicals in shrimp farming is a very common practice. Water and soil treatment compound, algaecides and pesticides, plankton growth inducers (fertilizer and mineral), feed additives, disinfectants, therapeutants etc chemicals are widely used in shrimp culture during the farming period. Apart from these, there are many antibiotics which are also used in shrimp culture on a routine basis. They are tetracycline, oxytetracycline, oxolinic acid, furazolidone, chloramphenicol etc. The water of the shrimp ponds become highly polluted with these chemicals, antibiotics and leftover food particles. This polluted water is directly released to nearby river/stream/canal after farming period. In the year 2016, from 5895 ha of shrimp farming area, approximately

15,572,942 US Gallon of water has been released to nearby river/stream/canal after shrimp farming period. Apart from this, the waste water from shrimp processing unit also pollutes the nearby area.

Table 6.4 Water salinity and pH in shrimp pond, river/stream/canal and tube-well of shrimp farm hot spot area of the study area for the year of 2012 and 2016

Parameters	**Year**		**Sampling location**		
			Shrimp pond	**River/stream/canal**	**Tube-well**
Water salinity (ppt)	**2012**	**Range**	9.0 - 15.0	8.0 -15.0	N.A*
		Average	11.5	11.25	<1
	2016	**Range**	8.0 - 13.0	9.0 -14.0	N.A*
		Average	10.75	11	<1
Water pH	**2012**	**Range**	8.3 - 9.4	8.0-9.7	7.17-7.36
		Average	8.7	8.5	7.32
	2016	**Range**	7.8-9.7	8.2-9.8	7.15-7.38
		Average	8.45	8.73	7.29

*Not applicable as salinity less than one hence could not be measured in the instrument because the instrument has no division below one.

6.3.1.4 Loss of vegetation cover

Analyzing the data of change detection matrix it is seen that from the year 2008 to 2016, approximately 31.31 ha of vegetation cover area are destroyed (decreased) only due to shrimp farming. The value indicates a decrease of 2.45% of the total vegetation cover area of the study area. From the year 2008 to 2012 the decrease in vegetation area is recorded as 12.55 ha and from 2012 to 2016 it is recorded as 18.76 ha. Ramnagar-I block has experienced highest loss in vegetation cover, which is 13.63 ha area. Desopran block has lost 8.14 ha of its vegetation covered area wherein Ramnagar-II the loss is recorded as 7.66 ha and in Contai-I it is 1.88 ha area. Indirectly many nearby plants are destroyed just in the name of saving the shrimp ponds from falling leaves (Figure 6.7).

In Desopran, Contai-I and Contai-III block many fresh water ponds are used for shrimp farming. In other words, fresh water tanks/ponds has been transformed into brackish water tanks/ponds. During this transformation, the trees around the pond side have been cut. Moreover the shrimp farms have been made beside the embankments of river/stream/canal; natural vegetation upon those embankments has been destroyed.

Figure 6.7 Affects of shrimp farming on vegetation cover: The image of 2008 shows vegetation cover around the road and the fresh water tanks/ponds. In the second image of 2016, emergence and expansion of brackish water tanks/ponds are seen for shrimp farming and subsequently, a clear loss of vegetation cover can also be displayed in and around the same area as tree shadow, fallen leaves are avoidable for shrimp farming.

The areas of Ramnagar-I and Ramnagar-II block where shrimp farming is happening in coastal wetland and saltpan area. Analyzing the previous images it has been found that there was plenty of shrub and mangrove type natural vegetation beside the shrimp farm areas. With the increase of shrimp farming area, the natural vegetation has gradually decreased. The value of natural vegetation along the coastal area is incalculable. It not only enhances the natural beauty but also creates a natural barrier which prevents cyclonic destruction. Moreover, it balances coastal and marine ecosystem. Because of the decrease in natural vegetation in coastal areas, the destructive effect of cyclone has increased and various types of animals and birds are becoming invisible. The Figure 6.8 is showing the loss of vegetation cover as a result of shrimp farming.

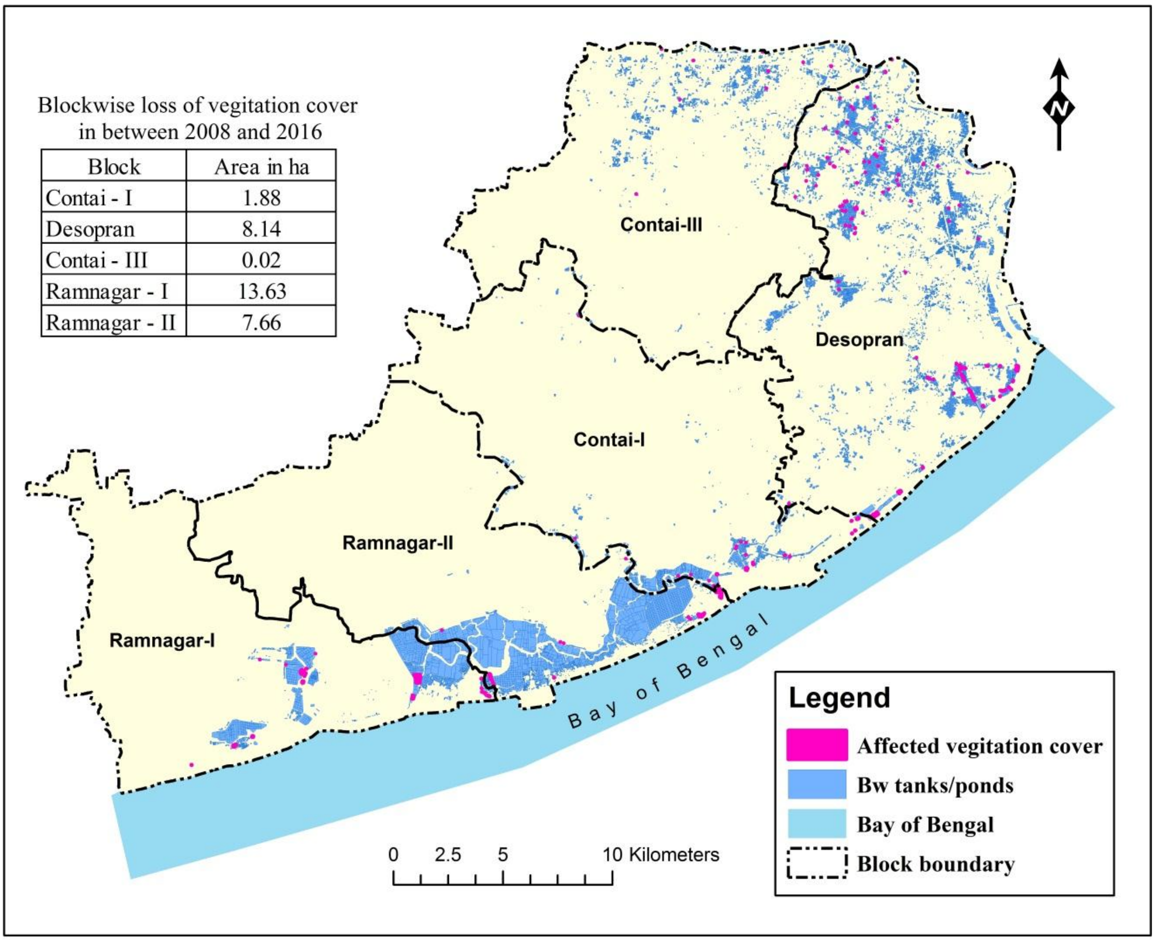

Figure 6.8 Affected areas showing the loss of vegetation cover as a result of shrimp farming

6.3.1.5 Air pollution

For high stocking density (>100/ m^2) in case of shrimp farming, the water needs more and more oxygen and for this purpose, the paddle wheels are used. Paddle wheel also generates water current and accumulates the waste to the centre. In five coastal blocks of the study area, total 70% of the area is used for intensive shrimp farming in which again in 90% of farms paddle wheels are operated by a diesel engine and in 10 % farms the paddle wheels are operated by electric motors. In 2016, approximately 4244 ha shrimp farms used a diesel engine to operate the paddle wheels. According to the farm technician for 3000 m^2 of shrimp farming area 6 number (10 paddles each aerator) of aerators are required in case of intensive shrimp farming, i.e. 3 diesel engines are required (2 aerators/ engine). Every day the diesel engines are run from 12 hours to 16 hours in the whole study area. Approximately 42400 number of diesel engines run 12-16 hours per day during shrimp farming period. The emission of carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NOx), particulate matter badly pollutes the air.

The use of the diesel engine is also increasing with the growth of shrimp farming day by day. Because of this shrimp farming hotspot areas are now turning into industrial environment now a day. In many places, it is seen that the farm owners rent those diesel engines from agents. Naturally, those machines are not properly maintained. On the other hand, kerosene oil is used in place of diesel that results in much higher carbon emission. So there is no doubt that shrimp farming causes air pollution. Depending upon the farming intensity and farming area, the villages in which the shrimp farming is happening, the spatial distribution of use of diesel engine in those villages is shown in Figure 6.9.

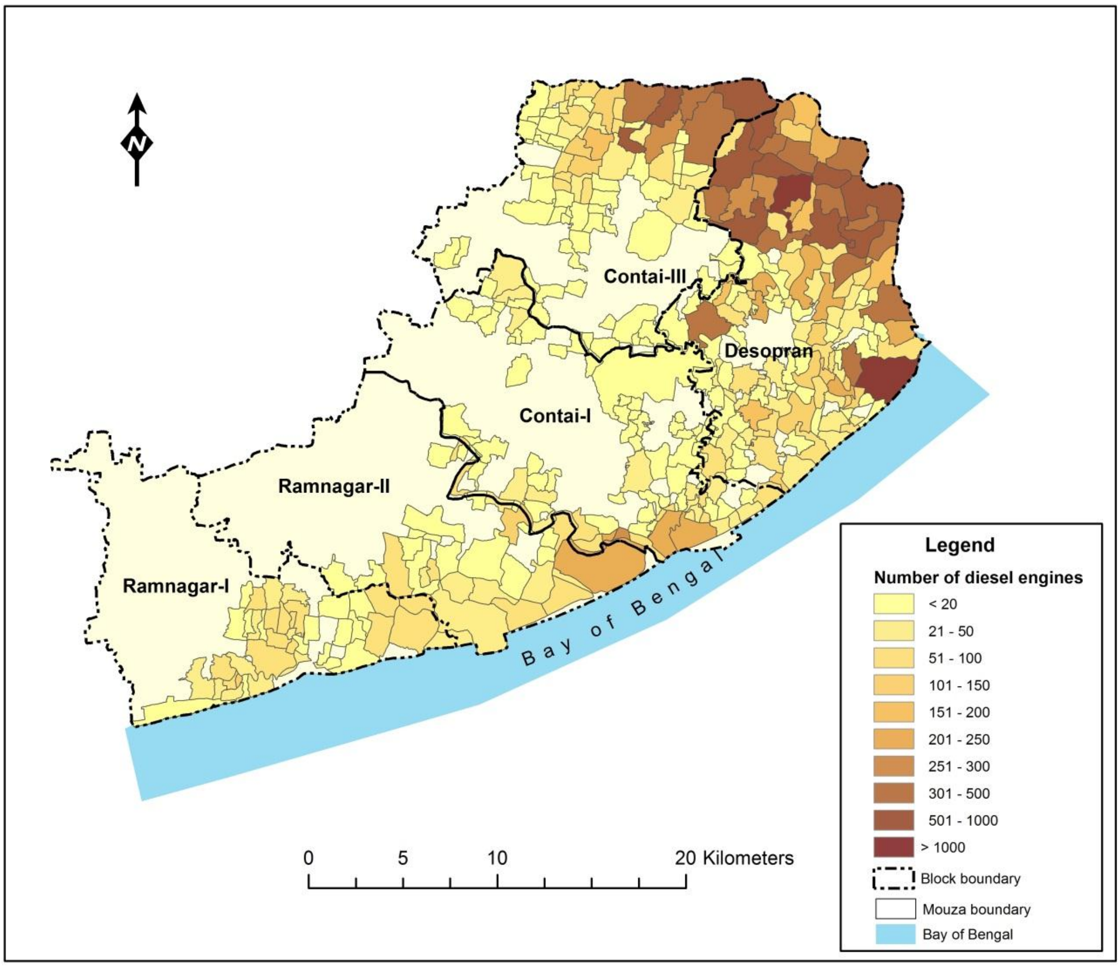

Figure 6.9 Spatial distributions of diesel engines in the shrimp farming villages on the basis of farming intensity and farming area

6.3.1.6 Embankment erosion

Saline water is needed for shrimp culture; hence shrimp farms are created close to tidal river/stream/canal. Sometimes it is also seen that people are doing shrimp farming on the riverbed. From change detection matrix it is again noticed that in between 2008 to 2016 total 26.28 ha of river beds are used in shrimp farming in which highest uses of river-beds seen in Ramnagar-II (10.30 ha) following by Contai-I (9.25 ha) and Desopran block (6.73 ha). To pour the water inside pond or release water to outside, inlet and outlet canals are made and those are joined unscientifically to nearby river/stream/canal. These things damage the natural embankment. To avoid the falling leaves over the shrimp ponds nearby grasses/plants are cut down and this also disturbs the natural embankment. Again shrimp farmers directly cut the embankments to set up machine/motors for paddle wheels (Figure 6.15D). To create new shrimp ponds or for scraping of pond bottom for shrimp farming after completion of one shrimp period, heavy earth-moving machine and tractors are used. Huge embankment damage is seen in this time.

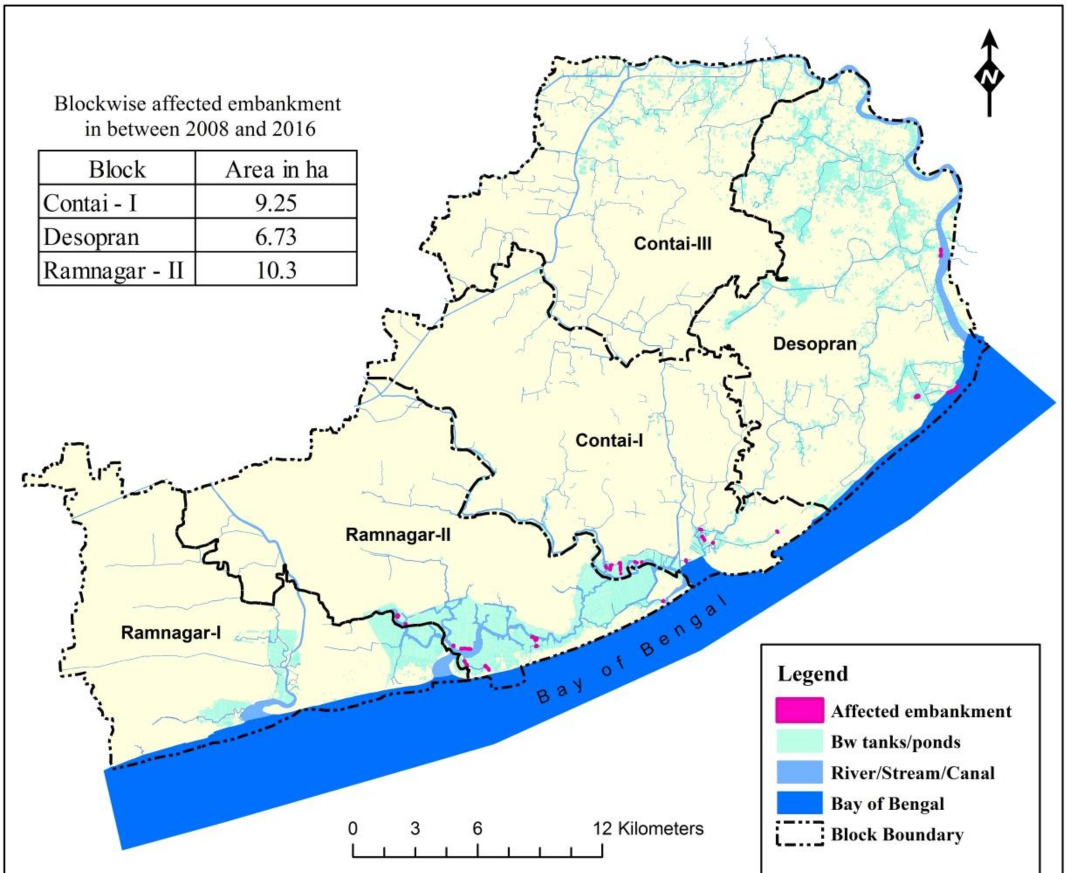

Figure 6.10 Affected parts of embankment as a result of shrimp farming

Thus, in those study areas with the increase in shrimp farming, embankment erosion also increase. The rapid sedimentation of river/stream/canal is the effect of this erosion. As a result, the natural load capacity of river/stream and canal and the natural strength of embankments are decreasing. So, during the accession rain and high tide the embankment collapse and flood the agricultural lands and villages which are beside them. This is negatively affecting the village economy. So because of the shrimp farming, this type of manmade flood has increased. In some areas, the embankment has been modified for shrimp farming inside the river bed. Thus for the personal benefit of shrimp farmers the people of the whole area is suffering.

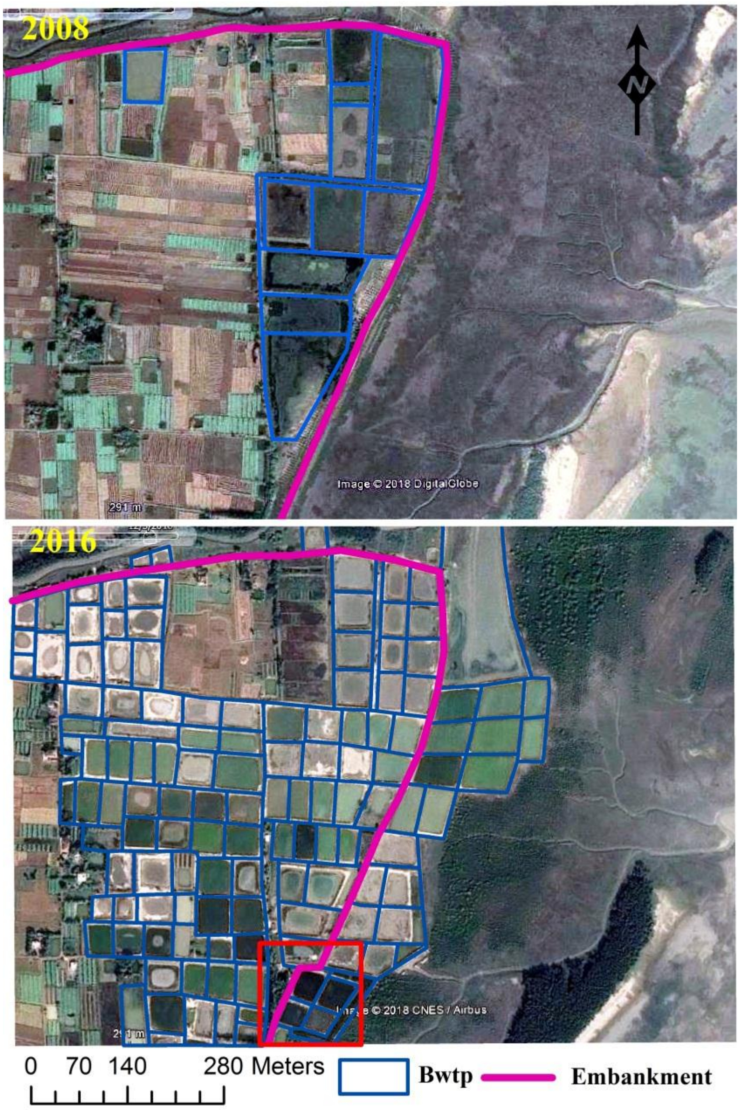

Figure 6.11 Shrimp farming in river beds and associated change and modification of embankment: Comparing both the images, it is clear that Image 2016 shows large

growth of shrimp ponds with respect to image 2008 of the same area. Image 2016 shows the expansion of shrimp ponds in the river bed portraying the use of river beds for shrimp culture. The embankment is shown in pink line which also differs from 2008 to 2016. For the purpose of shrimp farming, the embankment is modified in 2016 and change is demarcated here with the red box.

6.3.2. Impacts on economic environment

The higher profit of shrimp farming motivates people to work in this industry. According to the primary survey, a shrimp farming worker can earn much more compared to the traditional agriculture. Because of the higher earning, the per capita income is increasing. Local people have started to live a standard life and now are capable of sending their children to good private schools. Family quarrel related to money is almost over because the shrimp farming worker is now able to provide all the necessary facilities to his dependents. They are also now capable to save money for their future too. On the other hand, the huge production of shrimps in the coastal area made it possible to export more and more to the foreign countries and hence highly contributing to the economic growth of the country. But because there is no such huge local market of shrimp in India, the earning of the shrimp industry is dependent on foreign markets only.

6.3.2.1 Economic return of the shrimp production

To estimate any return or profit of farm it is required to know the cost of the farming. The people of the study area had started doing shrimp farming leaving behind the traditional agriculture. In this present study to compare the profit margin of both paddy cultivation and shrimp farming in five coastal blocks data has been collected from 30 rice farmers and 50 shrimp farmers. The requirement for both the farming is asked along with the information of quantity and also the data has been collected for total production after farming. These variables are multiplied with the market value of 2018 to estimate the total cost and hence to find the total return. This calculation is made w.r.t one-acre area and in Indian Currency INR (1 USD =69.92 INR).

The cost of shrimp farming is divided into two parts- Setup cost and Running cost. The Setup cost includes digging cost, store room set up, tools and equipment etc. Running cost means cost of shrimp seed, feed, cost of labour, medicine, diesel, electricity, land rent, maintenance cost etc. (Table 6.5). In case of small farmers, in different phases of farming along with the hired labour, family members (labours) are also engaged in work. In this case it is difficult to calculate the cost of family labours. In case of large farmers, they are mostly dependent on hired labours. Generally, for shrimp farming, the set up cost is assumed for 5 years (considering farming once in a year). Hence, for shrimp farming, total cost = running cost + $1/5^{th}$ of setup cost.

Table 6.5 Average (and range) cost of farming in Rs/acre of shrimp production

Cost type	Variable items	Cost per unit	Cost range	Cost mean
Setup cost	Digging	Area	82000-96000	90000
	Tools & equipment	Numbers	65000-78000	71000
	Store room & others	Materials and labour	10500-14000	12000
	Total Setup cost			**173000**
Running cost	Shrimp seed	Count	58200-66000	61500
	Feed	Kg	210000-292000	275000
	Medicine	Gram/ml	72000-85000	76000
	Labour	Person/ monthly salary	46500-53000	49000
	Diesel	Ltr	32000-37000	34000
	Electricity	Unit	3500-4000	3700
	Maintenance/Cleaning		18000-26000	22000
	Others Cost		4200-8000	6000
	Land rent	Area	38000-46000	41500
	Total Running Cost			**568700**

Source: Primary Survey

In the case of paddy cultivation, there are three different costs involved. Those are- seeding cost, transplantation and field maintenance cost and harvesting cost (Table 6.6). In this case land rent has been ignored because the farmers having own land hired labours for farming and the farmers those are doing farming in other's land (Bhagchasi) have their own labours for farming. Total Cost for rice cultivation = seeding cost + transplantation and filed maintenance cost + harvesting cost.

Table 6.6 Average (and range) cost of farming in Rs/acre of paddy production

Cost type	Variable items	Cost per unit	Cost range	Cost means
Seeding cost	Field ploughed	Area	220-275	255
	Seeds	kg	900-1250	1050
	Fertilizer & Pesticides	kg/ml	260-350	300
	Organic Fertilizer	Kg	120-180	145
	Irrigation	Hrs.	350-465	400
	Labour	Man-days	800-1200	1000
	Total seeding cost			**3150**
Transplantation & field maintenance cost	Field ploughed	Area	3150-3600	3350
	Labour	Man-days	6800-7500	7250
	Fertilizer & Pesticides	kg/ml	3600-4200	3850
	Irrigation	Crop period	2800-3200	2950
	Other Cost		3050-3500	3200
	Total transplantation & field maintenance cost			**20600**
Harvesting cost	Labour	Man-days	5200-6200	5550
	Carrying cost	Distance	400-750	550
	Total harvesting cost			**6100**

Source: Primary Survey

For both the farming the net return is calculated by deducting the total cost from gross return (Table 6.7). From the calculations shown in the table below it is seen that the return from total rice cultivation is Rs 15750 whereas return from shrimp culture is Rs 196700 which is approximately 12 times higher compared to rice cultivation. But if we consider the investment values the shrimp farming involves higher risk because of its high investment compared to rice cultivation. If at any problem arises or virus infection spreads shrimp farmers go through great loss which is not a factor for rice farmers.

Table 6.7 Cost and return of shrimp culture and paddy farming

Culture/farming	Production in kg		Market price/kg		Gross return	Total cost	Net return
	Range	Mean	Range	Mean			
Shrimp	1850-2400	2000	360-440	400	800000	603300	196700
Rice	2500-3100	2850	13-18	16	45600	29850	15750

6.3.2.2 Employment generation

Shrimp farming has a positive impact on employment generation. Many unemployed people has got the opportunity to work on the shrimp farms and are really earning good money. According to collected data of the study area, approximately 5 people work per hectare which is equal to 2 people per acre of land involved in shrimp farming, hence 29,000 workers work over 5 blocks. Indirect employment generation due to shrimp farming is also appreciable. Many people have also got an opportunity to work in the related industries like ice factory, feed industry, machine repairing job, processing unit etc. In recent years it is also observed that because of the development of the area due to shrimp farming, tourism industry has also grown up and many people are now engaged in tourism related activities.

Whereas in other farming labour is required during various stages (seeding, transplantation, harvest etc.) of the farming, in the shrimp farming labour is required for the whole farming period. If the farming is done twice a year then the possibility of employment is generated for 6 to 8 months. Moreover, the wages of labour is also much higher which is 8 to 12 thousand. Naturally, income of labours also increased along with the employment generation. So in the coastal areas, the shrimp farming is invaluable to drive away poverty and unemployment. As per the report of Commission for Agricultural Cost and Pricing (CACP), the average labour required for paddy cultivation in West Bengal is 141.4 man-days per hectare which is equal to 57 man-days per acre (considering one man-day equal to 8 working hours) (GOI, 2005). Comparing the labour required for paddy in the state and the labour input used by shrimp farmers in the study area, it can be said that labour used by shrimp farmers was much higher than that for paddy in the state.

The requirement of labour is less in traditional farming in comparison to scientific or semi-scientific. In case of scientific farming it is noticed that, the requirement of labour for per acre farming is much more than the case of traditional farming (almost 2.5 times). Where there is an average of 87 man-days required for per acre traditional farming, there are 223 man-days required for scientific farming. Again in case of scientific farming, the necessity of labour is more in medium farms than the small farms because here the use of mechanism (pump, aerators etc.) is comparatively more. Where, in case of small farming an average of 230 man-days are required for per acre farming, there for medium farming 245 man-days are required. On the other hand, requirement of labours is less (195 man-days/acre) in case of large farming than both small and medium farming. Here, the mechanism function is less. So the culture is not done in entirely scientific way in large farms, it is done in semi-scientific method. Besides, in case of traditional farming, an inverse relationship is noticed between the labour use and farm area, where, per acre man-days will be required more if the farm size is small and per acre man-days requirement will be less if the farm size is large as in this case, the use of family labour is more. Traditional farming is happening in five study blocks of Ramnagar-I and Ramnagar-II. The details of necessity of labour for various category farming is shown in the statistics Table 6.8.

Table: 6.8 Use of labour in traditional and scientific shrimp farming (man-days/acre) across different categories of shrimp farm

Farming system	**Categories of shrimp farm**						**Total labour (average man-days/acre)**
	Small (<2.5 acres)		**Medium (≥2.5-5acres)**		**Large (≥5 acres)**		
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**	
Traditional	90-110	100	75-90	82.5	70-85	77.5	86.66 (87)
Scientific	220-240	230	230-260	245	180-210	195	223.33 (223)

Source: Primary survey

6.3.2.3 Loss of rice production

Shrimp farming is also responsible for the loss of production of rice in the study area. Due to the huge release of saline water from the shrimp farm nearby rice fields get highly affected which results in lowering the rice production. Since the agriculture land is reduced drastically in areas (ha) due to its conversion into brackish water tanks/ponds the production of the rice is going down badly. By analyzing the statistics for the years 2008, 2012 and 2016 it is observed that from 2008 to 2012 total 530.38 ha agriculture land was decreased and from 2012 to 2016 the decrease in agriculture land was noticed to be 1414.94 ha. The block wise statistics is shown in Table 6.9. The local food security is highly affected due to the conversion of multi-use agricultural land to shrimp farms.

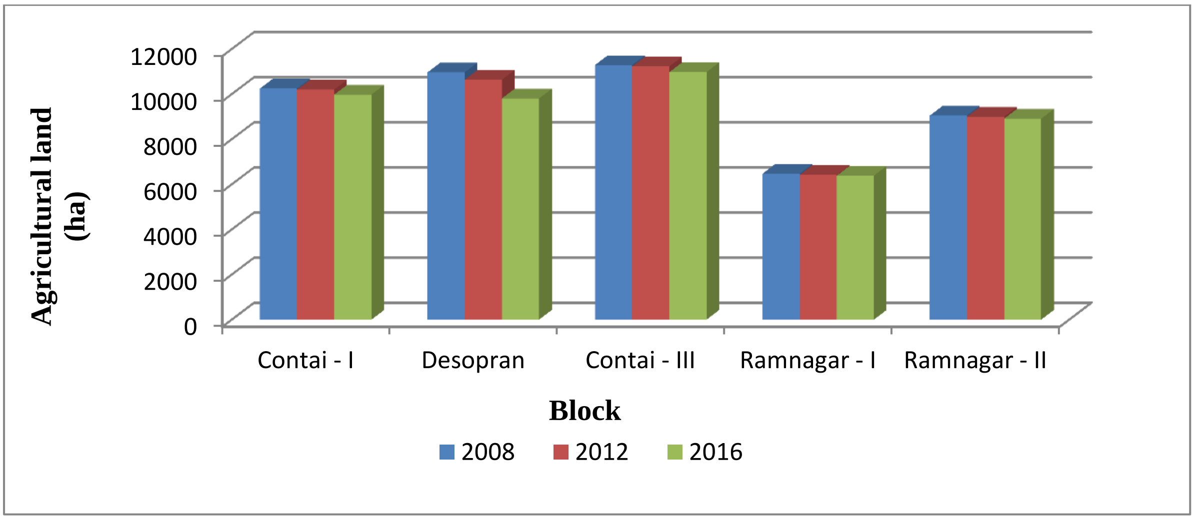

Figure 6.12 Bargraph showing block wise variation in agricultural land for the study year 2008, 2012 and 2016

Table 6.9 Block wise variation in agricultural land for the study year 2008, 2012 and 2016

Block Name	Year wise Statistics of Agricultural land (ha)			Decrease of Agricultural land (ha)	
	2008	2012	2016	2008-2012	2012-2016
Contai - I	10239.2	10195.01	9974.5	44.19	220.51
Desopran	10958.27	10631.82	9804.51	326.45	827.31
Contai - III	11285.9	11224.57	10973.73	61.33	250.84
Ramnagar - I	6464.02	6413.09	6382.31	50.93	30.78
Ramnagar - II	9043.17	8995.69	8910.19	47.48	85.5

An observation has been made in agricultural lands of ten (10) shrimp pond adjacent areas (in the time of Boro paddy cultivation, i.e. during November and December), where the shrimp farming is going on for more than 5 years. Here, after the observation of the height of paddy plants, after 20 days of transplantation (before 30 days), it is seen that the growth of paddy plants is not the same on everywhere of the paddy field. In shrimp pond adjacent land (within 5 meter), the growth of the paddy plants are absolutely less, as much as it was at the time of transplant. But at the distant areas (more than 10 meter distance) the growth is more (average growth 8 cm).

In Figure 6.13 it is seen that, where, the height of paddy plants, after 20 days of transplantation in the areas adjacent to shrimp ponds is near 10 cm, there in distant area the height of paddy plant is 7 inch i.e. 18 cm. Not only that, but maximum paddy plants have also dried up. The reason here is the fact that paddy is salt sensitive monocot (Maas and Hoffman, 1997). Especially it becomes too sensitive in the seeding and transplanting stage (Zheng et al., 2001). Hence, a little difference in salinity causes negative effect on these. The present study shows that the difference of salinity (EC) between the agricultural lands nearby shrimp ponds (less than 5m) and distant to shrimp ponds (more than 10m) is less than one (Table 6.3). Still at the transplanting stage of paddy, when the paddy plant is transplanted from seeding fields of comparatively less saline area to more saline agricultural land (near to shrimp pond), then the natural growth of the plant is hampered or plants are dried up. For this reason, the cost of paddy cultivation increases but the total production decreases.

Figure 6.13 Affects of shrimp farming on paddy fields: In the picture above, in both cases the crop is sown at the same time (viz. 20 days after transplantation) and in the same field. In Fig A, the paddy is nearer to the shrimp pond i.e. less than 5 meters distance. Here, due to more salinity after transplantation it becomes dry, has no growth. On the other hand in Fig. B, the paddy is at a distance of more than 10 meters from the shrimp pond which shows more healthy plants due to less salinity of soil.

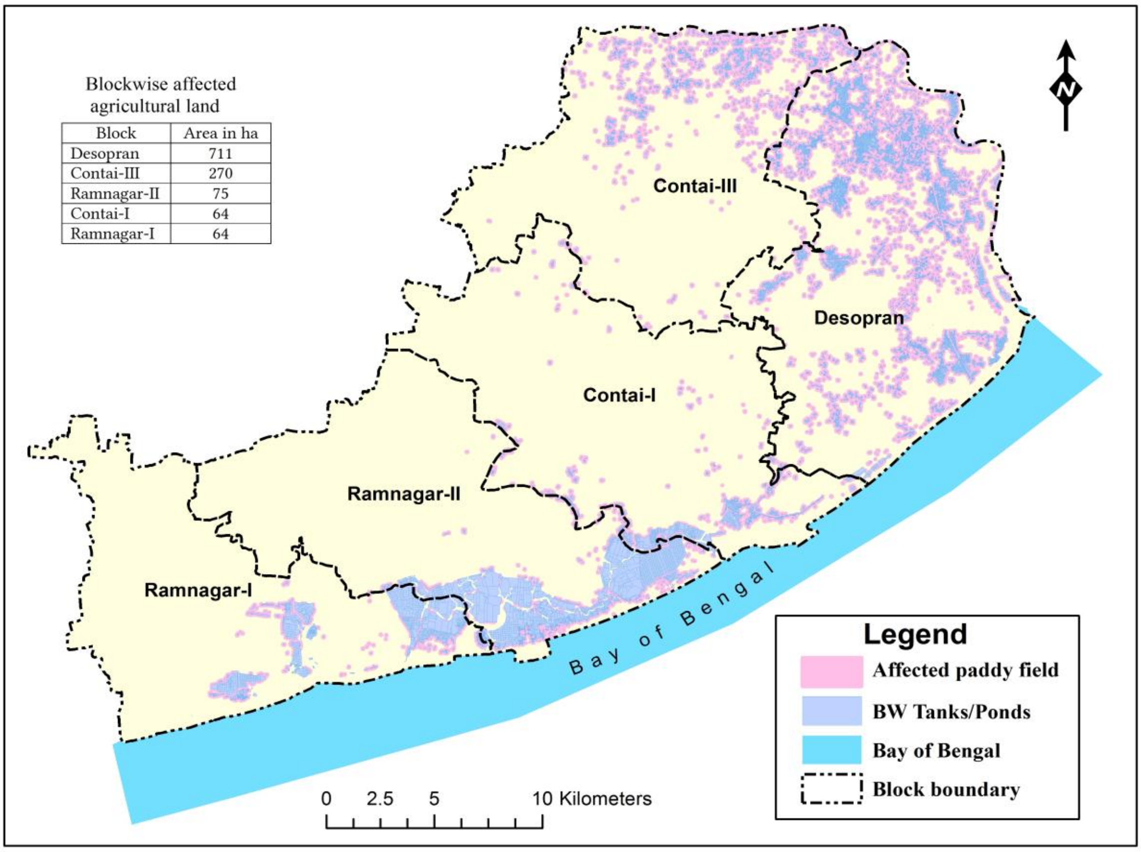

Figure 6.14 Affected paddy field adjoining shrimp ponds due to increase of soil salinity

6.3.3 Impacts on social environment

Transformation of agriculture based economy to aquaculture based economy obviously brings some social changes, where the traditional values and customs of society are often sacrificed.

6.3.3.1 Impacts on health and education

After interviewing the shrimp farmers and labours, too many health related issues were noticed. The labours work almost 24 hours per day, to maintain the shrimp ponds. Most of the time they don’t even have enough time to have their food on. Because of these, they are commonly affected by gastritis pain, insomnia, body ache, weight loss and some sexual diseases. Mosquitoes lay eggs in the nearby areas and their population increase rapidly, the disposals of shrimp waste into the water bodies also increase the diseases caused due to contaminated water bodies. The women workers who work in shrimp processing are highly affected by skin diseases. A worker named Nakul Mandal has informed that he had been working in shrimp farm for 10 years, but due to extreme gastritis, he had to leave his job. From his experience, he said that it is really very difficult to work at night and during dawn. To do the feet point checking or to start and stop the machine at night is too risky and he has been injured many times during his working period. He had also faced snakes and foxes commonly in this field. The other labours have also agreed to his statement. A shrimp farmer named Khudi Das has explained his experience and said that there is always a high risk involved with shrimp farming as it's an investment of a lot of money. Shrimp farmers stay tensed about their profit and loss conditions and hence they suffer from hypertension, headache, insomnia, high pressure, diabetes etc. When asked about education people said that there is no such noticeable change in this field. But the children of established farmers who earn good money from shrimp farming go to town for studies. A big investor Chintamoni Mandal himself opened a big English medium school in Contai town.

6.3.3.2 Deterioration of moral value

The local people of the villages where shrimp farming takes place they know only one thing that shrimp farming means money and shrimp farmers are very rich people. Because shrimp farming involves huge money, many farmers do not want to take a chance and give them money time to time. This becomes the habit of some bad people and many others get influenced by them to earn easy money. These people are not concerned about the adverse effect of farming on their own agricultural field or the nearby area and just try to make fast money. Again in any social function or meet the shrimp farmers act like celebrities and people value them more just because they have huge money. Few farmers also think that they are superior and their behaviour to the common people change drastically. The shrimp farmers are not keen on sharing information regarding their shrimp farming. During the field visits it was noticed that unlike the paddy farmers who are more than willing to share and discuss regarding their occupation, the shrimp farmers tend to be more secretive. Lack of social behavior is noticed in the case of shrimp farmers whenever they are asked about their farms and farming.

6.3.3.3 Alcohol addiction

Because the shrimp farming labours have to work almost 24 hours per day during the farming period, the shrimp farm owner give them alcohol and make them work more and more. It is interesting that the farm who gives more alcohol to its labours becomes the most popular farm of the area. This daily consumption of free alcohol during the farming period becomes their habit and after five-six months when they leave the farms they are unable to avoid that habit. Their health condition becomes worse and also they waste too much of their money. They are unable to realize that the money they are wasting every day in alcohol is earned after continuous hard work for a long period. Although the earning of shrimp farming is more than traditional agriculture, the labours are unable to improve their economic conditions due to this bad habit.

6.3.3.4 Impacts of social crime

The coastal paddy farmers have become victim in the hand of shrimp farm owners. Many times conflicts are going on between shrimp farm owners and paddy cultivators of coastal areas and end up through blood shedding incidents. Later as a result of this, it is seen that the local government always supports the powerful shrimp farmers. In a recent clash on February 24, 2018, a local political leader (Nantu Pradhan) was killed and three others injured after some farmer shot them during a fight over shrimp farming in Bhagbanpur (Times of India, 27th Feb, 2018). The head of the state got involved as an intermediary to manage the situation. Because of many other issues including forceful land occupation, territorial disputes etc. the farm owners got involved in crimes and several murder cases have been reported.

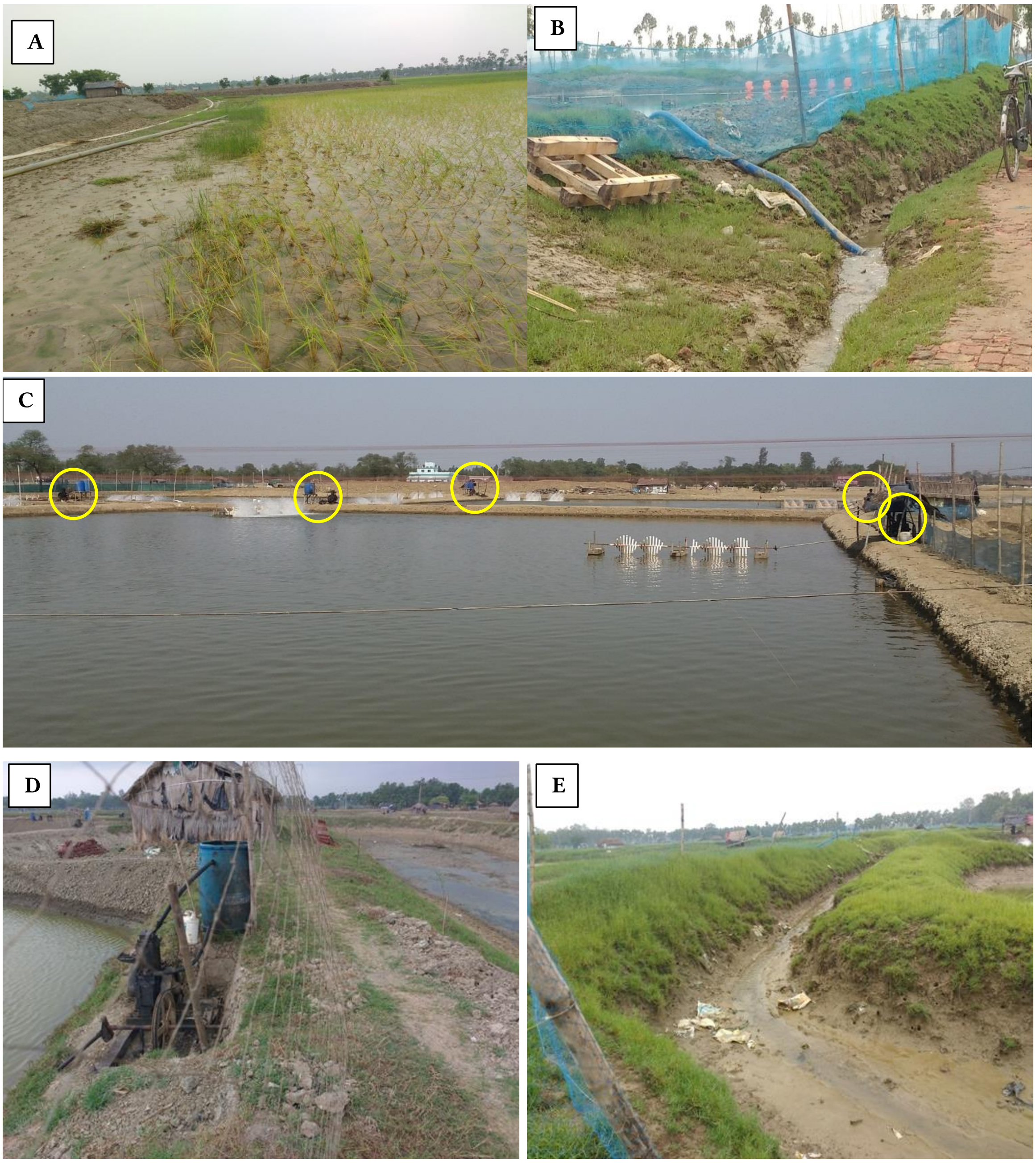

Figure 6.15 A) Shrimp farming affected agricultural land B) Releasing polluted water of shrimp pond directly to the nearby canal without any treatment of wastewater C) Use of Diesel Engine to run the paddle wheels of shrimp ponds D) Destroying embankments to set up the Diesel Engine E) Solid waste material of shrimp farming polluting the environment.

6.3.4 Assessment of the impacts of shrimp farming based on Leopold Matrix

The perception about block-wise spatial distribution of shrimp farming on physical and cultural elements are assessed separately through Leopold Matrix. Both positive and negative impacts have been noticed in the 5 blocks of shrimp farming area. The scale of importance in the Leopold Matrix ranges from 1 to 10, where the importance increases with the increasing value with 1 being least important and 10 being the most important. Further to show the impact is beneficial or adverse, plus (+) or minus (-) signs can be used to indicate positive and negative impacts. The scale of magnitude can also be considered on a range of 1 to 10. In each interacting cell, two numbers are recorded, column total represents the impact of individual project action on all environmental components. These various environmental components are very closely inter linked with each other. If one component is disturbed for some reason, then its effect is noticed on the other elements. In the study, with the help of simple interaction matrix, a valuable idea of the impacts has been shown with numeric score.

Both the physical and cultural impacts are directly proportional in nature, hence with cultural growth which results due to the betterment of the financial condition of the farmers we can visualize physical damage i.e increase in soil salinity, losses of the vegetation cover, embankment erosion etc. to nature with increasing commercial shrimp farming. But the rate of positive impact is much less than that of the negative impact on the environment. Amongst the 5 studied blocks maximum positive impact has been noticed in Desopran and Contai-III blocks whereas these are the blocks which have also been affected the most by the negative impact i.e the damage over the environment. Table 6.10 shows the result of the Leopold Matrix.

Table 6.10 Environmental impacts evaluation on five coastal blocks using Leopold Matrix

Name of the Blocks	**Block wise impacts of shrimp farming on natural and human environmental elements**												Total score	
	A. Physical & chemical characteristic								B. Biological condition					
	1. Earth		2. water		3.Atmosphere		4.Processes		1.Flora		2.Fauna			
	c. Soil	d. Landform	a. Surface water	c. Ground water	a. Quality (Gases, Particulates)	b. Tempe rature	b. Erosion	c. Deposition/ Sedimentation	a. Tree	b. Shrub	c. Fish	g. Endanger ed species	+	-
Ramnagar-I	-7×2	-5×8	-3×5		-2×3	-3×2	-2×5	-2×4	-2×5	-4×7	+3 ×5	-2×5	15	147
Ramnagar-II	-5×4	-3×5	-5×5		-2×5	-2×4	-2×5	-2×5	-2×7	-6×4	+4×4	-3×4	16	148
Contai-I	-7×5	-7×5	-5×6	-2×2	-2×5	-2×5	-3×5	-3×5	-2×6	-3×4	+3×3	-2×4	9	186
Desopran	-9×5	-5×5	-5×8	-2×5	-2×8	-3×4	-5×5	-5×5	-2×3	-2×5	+5×5	-2×4	25	222
Contai-III	-8×5	-5×4	-5×9	-2×6	-2×7	-3×5	-4×5	-3×6	-2×2	-2×4	+3×4	-3×2	12	202

Name of the Blocks	C. Cultural factors							D. Ecological Relationship		Total score	
	1.Land use	4. Cultural status				5.Man-made facility and activity					
	e.Agriculture	a. Life style	b. Health and safety	c. Employ ment	e. Social value	b. Transportati on network	d. Waste disposal	a. Salinization of water resources	b. Salinization of surficial material	+	-
Ramnagar-I	-4×4	+3×2	-1×3	+4×7	-1×2	+2×3	-2×4	-2×3	-1×2	40	37
Ramnagar-II	-5×4	+3×2	-1×3	+5×6	-1×2	+2×2	-3×4	-2×4	-1×2	40	41
Contai-I	-6×5	+5×3	-2×3	+5×7	-1×3	+3×3	-4×5	-3×4	-1×3	59	74
Desopran	-7×7	+5×3	-2×4	+6×8	-1×3	+4×4	-5×6	-4×4	-2×3	79	106
Contai-III	-6×7	+4×3	-2×3	+6×7	-1×2	+4×3	-5×5	-3×4	-2×2	66	91

+ = Positive impact; - = Negative impact; Impact Magnitude: 1-10; Impact Significance: 1-10

6.4 Summary

The above mentioned findings and facts clearly explain that the most causative agent of environment degradation in the coastal zone of West Bengal is unplanned shrimp culture. Local people have already realized its high-profit percentage which is much higher compared to paddy farming and hence they have started doing shrimp farming blindly focusing just on money and not following any proper measures. The highest consequence is experienced by traditional agriculture. Agriculture land is decreased drastically and with the increase of brackish water tanks/ponds, the remaining paddy land is experiencing salinization and hence badly affecting the production of tradition crop –Rice. People are destroying natural embankment for setting up machinery to run the paddle wheels of the farms. Many inlet and outlet canals are created to release polluted pond water directly to the nearby river/stream or to use the water from river/stream to shrimp pond. This badly weakens the strength of the natural embankments. Due to unplanned intensive shrimp farming in the study area, the flow of river/stream is forced to change too. Vegetation covered area is also noticeably affected due to non-scientific and unplanned culture. There is no respect and value for the ecological balance and people become more greedy and ready to do anything just for the money. The tanks owners are desperate for their personal benefit and do not care for public interest or the environment or scientific method adoption. The administration is so long indifferent and seems to have no awareness of the problem.