ENVIRONMENTAL IMPACT ASSESSMENT OF AQUACULTURE IN COASTAL AREAS OF RAIGAD DISTRICT, MAHARASHTRA

Priya Kanojia[1*], Sudhakar Pardeshi[2]

ABSTRACT:
The coastal region is an important region for a habitat of wildlife, food source, resources and minerals, recreation area, beneficial location for industries (Carter, 1988). Coastal regions provide invaluable ecosystem services for human in direct and indirect way. Due to their precious environment and resources for human, economic and cultural activities, they have attracted huge population and developmental activities. All these have created pressures on coastal environment, inducing rapid changes (Mimura, 2008). Coastal zones are very sensitive areas and all the human activities are affecting the area and are of important environment concern now. Although, human activities like aquaculture, mining and tourism are helping to boost economy and providing employment opportunity to the local people but they are also polluting and creating harm to the environment to a great extent.
The paper presents the study of environmental impacts of aquaculture activity along Mhasla creek and Shriwardhan Bay area of Raigad District. This study has taken into consideration physical, geographical, ecological and socio-economic components to analyze the environmental impacts of aquaculture in different areas of Raigad district. To assess the impacts, Rapid Impact Assessment Matrix (RIAM) has been used and the results have been clearly showed that there are major negative impacts on the environment like loss of biodiversity, air, water and noise pollution, salinization in nearby farms and damage to coastal areas. The aquaculture sites in the study area are along the Mhasla creek and Shriwardhan bay area and are responsible for creek water pollution, loss of aquatic biodiversity and loss of coastal aesthetics in the area. As per EIA, the farm owners need to treat drain water in such a way which will not pollute the creek water but many farmers are failed to do the same. These negative impacts can be minimized by adopting sustainable and local environment suitable farming methods. However, aquaculture also has positive impact on the region like employment opportunities, financial and economic development of a region, state and ultimately the nation as well.

Keywords: Aquaculture, Environmental impact analysis, RIAM

[1*]Arihant College of Arts, Commerce and Science, Bavdhan, Pune, India, priyakanojia18@gmail.com
[2]Department of Geography, Savitribai Phule Pune University, Pune, India

[*]**Corresponding Author:**
[*]Arihant College of Arts, Commerce and Science, Bavdhan, Pune, India, sdpardeshi@gmail.com

DOI: 10.53555/ecb/2022.11.10.74

Introduction:

The uncontrolled expansion of aquaculture activity in the region has resulted in a range of negative impacts on the environment. As per the geographical location of the district, it has a great potential for different residential, recreational, industrial and commercial activities (District collector, Raigad Maharashtra, 2017). Agriculture, fishing, tourism, port construction, sand dredging, poultry, mining, steel industries, fruit processing industries, cottage industries are the major activities along the coastal region of the Raigad district. Among all these activities, aquaculture is one of the upcoming activities. It is growing rapidly in the district since 2000 in this region.

The study area, Raigad District is situated along the western coast of Maharashtra, India. The District has a long indented coastline of 240 km with number of creeks and estuaries. There are mangrove forests, marshes, tidal inlets and tidal flats widely spread along the coastal areas of Raigad district. The Supratidal and intertidal areas are usually best suited for aquaculture on coasts (Landu, 1992) and the supratidal, intertidal and mud flat areas are at higher extent in the region. Therefore, the region has great potential for coastal aquaculture, mainly for shrimp farming.

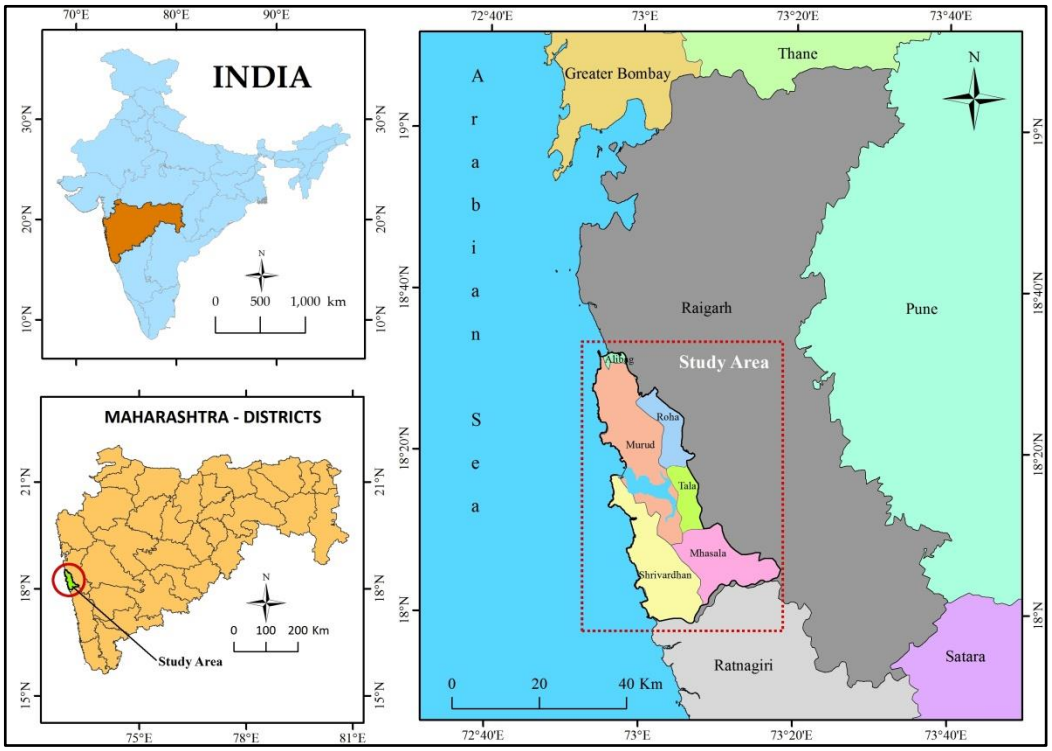

Fig. 1 Map of study area

The detail process of aquaculture includes cleaning of ponds, supplement liming, filling water, adding seeds and fertilizers, food for prawns, blooming, sampling, harvesting which includes effluent discharge, processing and packaging and marketing. All these process lead to the environmental pollution in direct or indirect way. Once the harvesting of prawns is completed, then the large amount of waste water has generated which is been discharged into the creek. As per the environmental act, the drain water can be discharged directly into the creek only after the scientific treatment on it. But the farmers are not following the scientific method of effluent discharge which leaves long term environmental impacts such as significant loss of biodiversity, increase in blooms, creek water pollution and decrease in the count of local fauna. Although aquaculture systems in their current form can be harmful to the environment, there are promising solutions that can improve the sustainability of aquaculture in the future.

Chemicals used in Aquaculture: Various types of chemicals are been used in entire aquaculture process. Hydrogen Peroxide is used for disinfecting water and equipment. Chlorine is applied periodically to control pathogens in water and equipment. Also, to control and maintain the water quality lime is used to adjust pH levels in water. Sodium Bicarbonate helps to stabilize water pH. Zeolite is used for ammonia removal. Activated Carbon helps in water purification by removing impurities. On the other hand some antibiotics and drugs ae also used to control

disease, to treat bacterial infections in fish. However, there are increasing concerns about antibiotic resistance and environmental impact of it. Antiphrastic Drugs are used to control and prevent parasitic infections in aquaculture species. Formalin is used as a bath treatment to control fungi. Copper Compounds are applied to control algae growth in ponds.

Some probiotics, enzymes are used to promote good bacteria to enhance the digestive systems of fish. In addition to this amino acids are used for growth and health of the fish.

Many aquaculture operators are using chemicals in the fish farming process. But they need to follow sustainable management practices to ensure the responsible and sustainable use of chemicals in aquaculture. Also, continuous monitoring of pond water quality and disease prevention strategies are also essential elements of successful aquaculture project.

Database and methodology

To study the impact of aquaculture, field studies have been carried out by selecting some sites of aquaculture. In the study area there are total 44 aquaculture sites out of which 19 sites have studied by simple random sampling method and 10 aquaculture sites have selected for RIAM calculation. Therefore, total 19 sites (260 ponds) of aquaculture along the Mhasla creek and Shriwardhan bay area have been studied.

Also, the assessment of impact of all these activities is qualitative and subjective in nature. Therefore, additional survey has been carried out to know the views of local people in nearby villages. To understand the impacts and other problems, villages which are in the vicinity of the aquaculture activities have been selected and interviews are carried through questionnaire. Also, the direct observations of the phenomena and aspects in terms of the process of aquaculture activity have done.

Rapid Impact Assessment Matrix

The Rapid Impact Assessment Matrix (RIAM) has been developed by Pastakia in 1998. It is a simple tool of scoring within the matrix. This tool is helpful to calculate both positive and negative environmental impacts. To study the environmental impact assessment four primary fields are focused that are:

1. Physical and Geographical aspects
2. Biological and Ecological aspects
3. Sociological and Cultural aspects
4. Economic and operational aspects

In all above four fields, physical and geographical aspects include land degradation, physical-geographical changes and pollution. Biological and ecological aspects include natural resources, biodiversity, conservation and pollution of the surrounding area. Sociological and cultural aspects include all the human aspects of the environment that affect the individuals and the communities of that area. Cultural aspects include the inheritance conservation and human development projects and programmes. Economical and operational aspects include the positive and negative impacts of human activities and also the changes in the environment whether it is permanent or temporary (Sundarakumar, 2010).

The impacts were studied, quantified and assessed on the basis of the field data which is collected through questionnaire survey and field observations. The positive or negative impacts have compared with Rapid Impact Assessment Matrix method (RIAM) which provides a transparent analysis of environmental impacts of human activities. The matrix is based on assigning weights to impact components to describe positive and negative impacts of the respective elements (Pastakia 1998).

The scores (Table 1) are assigned for the each environmental component like physical, biological, sociological and economical components and finally the environmental score is calculated with formula and range of impact is decided on the basis of range groups (Table 2).

An assessment criterion of RIAM is divided in two groups:-

(A) Criteria that can change individual environmental score obtained;

(B) Criteria that individual cannot change the environmental assessment score (Table 1)

RIAM Environmental Score (ES)

The final assessment of Environmental Score (ES) can be calculated as:

$$A1 \times A2 = AT$$

$$B1 + B2 + B3 = BT$$

$\mathrm{ES} = AT \times BT$ --- eq^{n} 1

Where,

A1 = Importance of the impact and effect; A2 = Magnitude of the change, damage and effect,

AT = Total of A1 & A2

B1 = Permanence of the impact-causing activity

B2 = Reversibility of impact

B3 = Accumulation of impact

BT = Total of B1, B2 & B3

ES = Environmental score

Evaluation and Scoring criteria of RIAM

Table 1 Description of the evaluation criterion

Evaluation Criteria	**Description**	**Scores**	**Description**
A1	Importance of the impact and effect	4	Important for the national interest
		3	Important for the regional interest
		2	Important for the areas out of the project
		1	Important for the local condition
		0	No geographical or other Importance
A2	Magnitude of the change, damage and effect	+3	Major positive benefit
		+2	Significant improvement in present condition
		+1	Improvement in present condition
		0	No change / impact
		-1	Negative change in present condition
		-2	Significant negative change in present condition
		-3	Major negative change in present condition
B1	Permanence of the impact-causing activity	3	Permanent: The project activity causing impact is meant to be a permanent one. For Example: Loss of bio-diversity, damage to coastal areas.
		2	Temporary: The project activity causing impact is temporal. For example: Water pollution and salinization in nearby rice farms.
		1	No change
B2	Reversibility of impact	3	Irreversible impact: The impact is irreversible, if the original condition is not restored after the activity is finished. Such activity has changed the environment permanently for a long period of time. For Example: Loss of biodiversity, deforestation.
		2	Reversible impact: The impact is reversible, if the original state will be restored after the activity is finished. For example: Air pollution, water pollution.
		1	Not applicable: Targeting the impact is impossible
B3	Accumulation of impact	3	Impact is cumulative. The project activity probably has combined impact with other activities in the same area. For example: Air pollution and waste water emissions, impact in general is often cumulative.
		2	Impact is non-cumulative
		1	No change/not applicable

(Source: Pastakia 1998 & Sundara Kumar, 2010**)**

Environmental range bands

After the calculation of environmental score, finally the impact class is assigned on the basis of criterion and values mentioned below:

Table 1 Environmental score range bands of RIAM

RIAM Environmental score ES	**Range Value (RV) Alphabetic**	**Range Value (RV) Numeric**	**Description of Range bands**
+108 to +72	E	5	Major positive impact
+71 to +36	D	4	Significant positive impact
+35 to +19	C	3	Moderate positive impact
+10 to +18	B	2	Positive impact
+1 to +9	A	1	Slight positive impact
0	N	0	No change
-1 to -9	-A	-1	Slight negative impact
-10 to -18	-B	-2	Negative impact
-19 to -35	-C	-3	Moderate negative impact
-36 to -71	-D	-4	Significant negative impact
-72 to -108	-E	-5	Major negative impact

Source: Pastakia and Jensen, 1998

RIAM of aquaculture

For the environmental impact assessment of aquaculture activity, four components have decided on the basis of aquaculture process (Table 3), which includes:

- Land reclamation
- Overburden removal and dumping on surrounding area
- Site development includes labour camp, construction of ponds and roads
- Aquaculture farming
- Use of chemicals for the preparation of ponds and in feeds
- Dumping of waste in nearby area of the site
- Releasing drain water in the creek or sea

The above mentioned aquaculture farming process has affected on many components that are land use, landscape, air and water, aquatic flora and fauna, water resources, socio-economic, risks and hazards and public health and safety.

5.3.5 Impact assessment of aquaculture

For the environmental impact assessment, ten aquaculture sites have been selected from different villages as case studies. The impact assessment of various aquaculture activities has been carried out towards four major areas that are Physical /Geographical, Biological /Ecological, Sociological / Cultural and Economical / Operational, where a number of components were identified (Table 3). All the above mentioned components were studied separately and evaluation criteria scores have been assigned on the basis of questionnaire survey. The collected information was used to calculate final environmental score and RIAM. The identified components selected for impact assessment and scores for various components are as follows:

Table 2 Identified components of aquaculture for impact assessment

Physical /Geographical		**Biological /Ecological**	
PG1	Landscape	BE1	Loss of biodiversity
PG2	Land/ Soil erosion	BE2	Loss of flora and fauna
PG3	Air Pollution	BE3	Loss of natural habitats
PG4	Water Pollution	BE4	Loss of aquatic animals
PG5	Noise Pollution	BE5	Ecological balance
PG6	Salinization in nearby farms	BE6	Solid wastes, Sewage and disposal
PG7	Geological changes	BE7	Loss of natural resources
Sociological / Cultural		**Economical / Operational**	
SC1	Replacement of labour	EO1	Damage to coastal areas
SC2	Loss of lives or Accidents	EO2	Effluent discharge
SC3	Housing / Infrastructure	EO3	Road Degradation
SC4	Education / Training	EO4	Financial development
SC5	Health aspects	EO5	Commercial establishments
SC6	Power / Water supply	EO6	Employment opportunities
SC7	Loss of aesthetics	EO7	Infrastructural Development

Source: Based on Pastakia, 1998

Aquaculture site 1 – Nandele

Table 3 Evaluation criteria scores and environmental score

Physical /Geographical		A1	A2	B1	B2	B3	ES	IC		**Biological /Ecological**		A1	A2	B1	B2	B3	ES	IC
PG1	Landscape	2	-3	3	3	3	-54	-D		BE1	Loss of biodiversity	2	-3	3	3	3	-54	-D
PG2	Land/ Soil erosion	2	-3	3	3	3	-54	-D		BE2	Loss of flora and fauna	2	-3	3	3	3	-54	-D
PG3	Air Pollution	2	-3	2	2	3	-42	-D		BE3	Loss of natural habitats	2	-3	3	3	3	-54	-D
PG4	Water Pollution	2	-3	2	2	3	-42	-D		BE4	Loss of aquatic animals	2	-3	2	3	3	-48	-D
PG5	Noise Pollution	2	-3	2	2	3	-42	-D		BE5	Ecological balance	2	-3	2	3	3	-48	-D
PG6	Salinization in nearby	2	-3	3	3	3	-54	-D		BE6	Solid wastes, Sewage	2	-3	2	2	3	-42	-D

	farms										disposal							
PG7	Geological changes	2	-3	3	3	3	-54	-D		BE7	Loss of natural resources	2	-3	3	3	3	-54	-D
	Average ES						**-48.86**	**-D**			**Average ES**						**-54.43**	**-D**

Sociological / Cultural		A1	A2	B1	B2	B3	ES	IC		**Economical / Operational**		A1	A2	B1	B2	B3	ES	IC
SC1	Replacement of labour	2	-3	2	2	3	-42	-D		EO1	Damage to coastal areas	3	-3	3	3	3	-81	-E
SC2	Loss of lives or accidents	2	-3	3	3	3	-54	-D		EO2	Effluent discharge	2	-3	2	3	3	-48	-D
SC3	Housing / Infrastructure	2	1	2	3	3	16	B		EO3	Road degradation	2	-3	2	2	3	-42	-D
SC4	Education / Training	2	2	3	3	2	32	C		EO4	Financial development	3	1	2	2	3	21	C
SC5	Health aspects	2	-3	2	3	3	-48	-D		EO5	Commercial establishments	3	1	2	2	3	21	C
SC6	Power / water supply	2	-3	3	3	3	-54	-D		EO6	Employment opportunities	3	-2	3	2	3	-48	-D
SC7	Loss of aesthetics	2	-3	2	3	3	-48	-D		EO7	Infrastructural development	3	-2	3	3	3	-54	-D
	Average ES						**-28.29**	**-B**			**Average ES**						**-33.00**	**-C**

Table 4 Assessment summary of all four components

Range	-108 -72	-71 -36	-35 -19	-18 -10	-9 -1	0 0	+1 +9	+10 +18	+19 +35	+36 +71	+72 +108
Class	-E	**-D**	-C	-B	-A	N	A	B	C	D	E
PG	0	**7**	0	0	0	0	0	0	0	0	0
BE	1	**6**	0	0	0	0	0	0	0	0	0
SC	0	**5**	0	0	0	0	0	1	1	0	0
EO	1	**4**	0	0	0	0	0	0	2	0	0
Total	2	**22**	0	0	0	0	0	1	3	0	0

Description: On the basis of evaluation criterion (Table 1) and field survey, scores (0 to 4 or -1 to -3) have assigned to each element of respective component on the basis of local conditions, impact level, reversibility and in increasing effect. Later on these scores have calculated by using formula (equation 1) to get environmental scores such as +1 to +9 or -1 to -9. Finally, with the help of environmental score, impact classes (Table 2) have assigned to each element of respective component (table 4 and 5).

For example, the result of Nandele aquaculture site shows that (Table 4, 5), there is a significant negative impact of aquaculture activity on surrounding environment.

In this way, the scores have assigned to all other aquaculture sites to know the environmental score and impact class.

Table 5 Average Environmental impact of Aquaculture sites

Sr. No	**Site Name**	**Avg. PG**	**Avg. BE**	**Avg. SC**	**Avg. EO**	**Average**	**IC**	**Impact description**
1	Nandele	-48.86	-54.43	-28.29	-33.00	**-41.14**	**-D**	Significant -ve impact
2	Mithagar	-46.86	-45.43	-20.00	-30.14	**-35.61**	**-D**	Significant -ve impact
3	Bhalgaon	-44.29	-51.43	-25.14	-29.86	**-37.68**	**-D**	Significant -ve impact
4	Rowala	-46.86	-50.57	-23.43	-25.86	**-36.68**	**-D**	Significant -ve impact
5	Majgaon	-39.71	-50.57	-23.43	-28.43	**-35.54**	**-D**	Significant -ve impact
6	Vadawali A	-42.86	-53.14	-20.57	-25.29	**-35.47**	**-D**	Significant -ve impact
7	Vadawali B	-42.86	-53.14	-20.57	-25.29	**-35.47**	**-D**	Significant -ve impact

8	Galsure A	-46.86	-53.14	-18.29	-26.29	**-36.15**	**-D**	Significant -ve impact
9	Galsure B	-46.86	-53.14	-18.29	-26.29	**-36.15**	**-D**	Significant -ve impact
10	Kolmandala	-33.14	-34.86	-13.71	-17.43	-24.79	-C	Moderate -ve impact
				Average of Averages		-35.47		

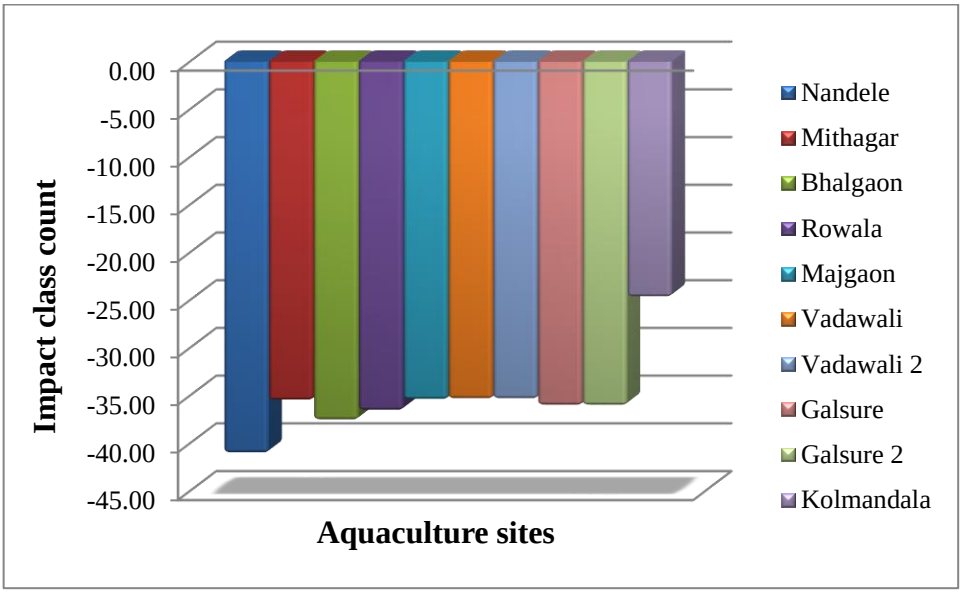

Fig. 2 Average ES of aquaculture sites

Results of aquaculture

Shrimp farming or aquaculture in the study area is totally depending on the coastal water. Aquaculture affects the environment by modifying the natural habitat, wildlife, soil, water and landscape of the area. The rapid development of aquaculture in the study area is observed since 2002 which resulted in mismanagement of natural resources and environmental degradation.

On the basis of scoring tables (Table 4, 5, 6), the aquaculture activity has significant negative physical – geographical and biological - ecological impact on the environment. Sociologically, except housing, infrastructure, education and training all other components have moderate negative impact. Also, there are some moderate positive impacts in economical and operational components that are in case of financial developments and commercial establishments in the study area. But rest two components that are physical and biological have significant negative impact (Table 6 and Fig. 2) on the environment as mentioned below:

1. Aquaculture activity is developed very fast in the study area but at the same time with development, the activity has raised many concerns too. The impact of aquaculture affected the local fauna and flora negatively, including threatened species. The effluents from aquaculture farms containing undesired chemicals like Urea, DDT (Dichloro Diphenyl Trichloroethane), oxidants and disinfectants which have contaminated creek water and are harmful to local ecosystem.
2. The intensity and the environmental impacts of aquaculture are due to the high intensity of production and the location of sites.
3. Also, due to salinization into nearby rice farms, many farmers have closed down the production in the Bhalgaon and Rowala villages.
4. Shrimp farming has an impact on environment in different ways. It is basically an intensive activity which involves an addition of solids, chemicals like sodium chloride, formalin, malachite green, methylene blue, potassium permanganate, hydrogen per oxide and glutaraldehyde and nutrients to the marine environment and it degrades environment in many ways that is construction of ponds caused impact on flora and fauna, farm discharges and waste products.
5. Location of the activity also matters a lot. Presently area that utilised for aquaculture along Mhasla creek is clustered and sites are very close to each other due to which disease spread is very common. Therefore, the clustered sites need to be diversified to the other potential areas of aquaculture. Also, the current management practices need to be regulated into sustainable practices to avoid environmental losses in the future.

6. Aquaculture activity results into the release of huge amount of waste into the marine environment. The waste is generated from the uneaten fish foods, undigested feed, indigestible compounds and excreta. The drain water contains the waste products which ultimately contaminates the creek water. The solid and dissolved waste includes harmful chemicals like carbonic acids, nitrogen acids and phosphorous and it also increases the risk of toxic algal blooms. All this creates air, water and land pollution in the surrounding area of the site.
7. Chemicals are used in the farming for different aquaculture processes that are pond preparation, pond cleaning and drying and to disinfect and improve the quality of pond water. The use of such chemicals raises a number of environmental concerns like pollution.
8. Aquaculture activity also releases huge amount of marine debris into the creek which is a hazard to marine flora and fauna. It has caused death to the aquatic animals of the coastal environment.
9. White spot disease is very common in shrimp farming. The aquaculture sites along Mhasla creek are affected by this disease due to the nearness of sites, high stocking density and incubation of disease organisms. With the help of some techniques, early detection of disease is possible to protect the valuable shrimps. The disease has got spread to adjacent farms and other aquatic animals through the drain water which is major concern in the study area. Due to which many farmers along the eastern bank of Mhasla creek has closed their sites due to heavy losses. This leads to irreversible loss to the environment.

The RIAM carried out for the aquaculture in the coastal areas of Raigad District, Maharashtra which indicates that all the aquaculture, sites are found to be under “Significant negative impact” category. Therefore, it can be concluded that, aquaculture activity experienced in the study area has resulted in temporary economic development but will lead to the major environmental degradation which will be the permanent one. All the negative impacts of the activity can be minimized by “Environmental Management Plan” which includes measures to save environmental degradation by following scientific and environment friendly methods of farming. The outcome of the study will be of great help to planners and decision makers to prepare strategies for “Environment friendly sustainable farming” which ultimately help to sustain coastal environment.

Acknowledgement: The authors would like to acknowledge site managers for providing information about aquaculture.

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