# *Chapter 7*

## IDENTIFICATION OF POTENTIAL SITES FOR SHRIMP CULTURE

The details of site suitability analysis for potential shrimp culture in the area under consideration through analytical hierarchy approach is discussed in this chapter. The different parameters considered in the unit of a potential site for shrimp culture is also presented. In this study, an attempt was made to identify and to give priority to the potential sites for shrimp culture, based on the suitable factors as well as constraints for sustainable development.

### 7.1 Introduction

In the recent years, aquaculture has grown really fast and globally it has contributed as growing food industry. But, the development and success of this industry comes with occasional observable failures which gives aquaculture the image of an activity associated with high risk (FAO, 1987). The sole reason behind the problems observed in aquaculture is because of lack of knowledge of the aquatic environment and ignoring problems related to production technology, as a reliable source of recourse assessment.

Proper site selection and monitoring of aquaculture farms are important management measure, which can largely check the negative impact on the aquaculture of the environment. Identifying potential areas and mentoring existing aquaculture farms adhering to CRZ norms (Costal Regulation Zone) will be helpful features for planning and for achievement of a sustainable aquaculture industry. The conventional method of site selection for aquaculture and preparation of maps are costly, less accurate and presents a picture of only a small area. For regional and sector studies of aquaculture principally the GIS has been applied till date, in which economic data, market data, socio-culture resources were used along with data related to site and resources (Meaden and Kapetsky,1991).

Suitable sites selection of aquaculture is a function of several criteria including environmental variables, infrastructural facilities and pollution source hazards. Considering various factors related to the environment, present constraints and future opportunities, a land-based aquaculture facility is sited. Consideration of environmental factors is important for avoiding many of the negative impacts that could result from setting up an aquaculture project. Decision making regarding the economic accomplishment, waste management, assessment of managerial activities on production (biomass), etc are the various sides of consideration for management of new aquaculture facilities. Most aquaculture ponds are constructed on earth, but there is always difference exists depending on the critical factors like soil type, water quality and availability. Earthwork construction, retention of water, leaching are always affected by the physical properties of the soil. To maintain aquatic life, sufficient water quantity is always a must need. In the places like Mekong Delta (Vietnam) and at Kung Kraben Bay, due to the proper planning, all the conflicting activities are separated carefully and now they are enjoying all the benefits of shrimp farming, mangrove conservation and protection of coastal areas. Accurate and comprehensive scientific data are main elements of the planning of natural resources (Barg and Phillips, 1997).

Shrimp culture planning is mostly applied focusing on management technique where zoning of coastal aquaculture is done to achieve improved sectorial plan. If considered all land-use possibilities, it has much wider goal (GESAMP, 2000). In aquaculture, water must be available in desired quantity and also at a considerable frequency to maintain necessary water elevation and to flush the pond. Various techniques for Multi Criteria Decision Making (MCDM) have emerged. Among these techniques, the simple as well as suitable ones are conjunctive screening, compensatory screening, and reasonably valued social contribution factor function and the analytical hierarchy process. Because of vast diversity seen in the sustainability conditions, it is not realistic to have a "universal" methodology, rather the existing techniques are sometimes preferably accepted or an improved form of the existing methodology is considered suitable for the problem. In the present study, the Analytical Hierarchy Process (AHP) is used because it is more logical and a well-structured representative of the decision problem and better option of executing priorities. AHP has also resolved the conflict between the tangible and intangible factors for their comparative importance and ranked them according to their priority (Saaty, 1986).

The study applies GIS techniques based on available data to interpret the potential areas extent available for aquaculture activities and to analyse the site suitability in the study area. The main objective is to identify and prioritize the potential site for shrimp culture using analytical hierarchy approach using Remote Sensing and GIS. So in this study, an attempt was made to identify and to give priority to the potential sites for shrimp culture, based on the suitable factors as well as constraints for sustainable development.

## 7.2 Materials and methods

Outline of the methodology for assessment of potential site for shrimp culture is shown in Figure 7.1. In order to determine sites for brackish water shrimp culture, different criteria were selected and compiled. The criteria were of two types: factor and constraint (Eastman & McKendry, 1995). Factor is measured on continuous scale and it is a criterion that enhances or takes away from the suitability of specific alternative under consideration. On the other hand, a constraint is for restricting the considered alternative. A few examples are forests, rivers, settlements, roads etc. By nature, a constraint is Boolean.

**Factors** – The most important parameters for potential site selection of shrimp culture are discussed here according to their importance.

1. **Available water**: Brackish water is one of the prerequisites for shrimp farming, therefore, it is an important parameter. Availability of brackish water is measured as the distance of brackish water river, streams, canal etc. from the farms.

2. **Soil quality**: Soil quality depicts the chemical, physical and biological properties. In this case, soil pH has been given more importance among the chemical parameters because normal to acidity soil is considered suitable for shrimp farming.

3. **Agricultural land**: Agricultural land is another important factor for the site selection of shrimp culture in the study area. It is because for the last few decades shrimp culture was practiced following the traditional method in the wet land and salt-pan areas of the study area. Currently scientific or semi-scientific method is followed for shrimp farming. At present, single cropped lands which are nearby the brackish water sources should be given prominence over double/triple cropped lands for renewed shrimp culture in the area because due to excessive use of double cropped lands, the production of the principal food crop paddy will be decreased hampering the local food security.

4. **Distance to road**: As there is a necessity of feed in huge quantity for scientific shrimp farming, there is also need of heavy farming equipment like diesel engine, electric motor, paddle wheel, iron pipe, iron chain etc. Hence, the distance of shrimp farm from the road is another important factor to be considered.

5. **Distance from local market**: Market is also an important parameter. As 75% to 90% of shrimp is exported, the importance of local market for selling the shrimp may be less but it is significant for other necessary materials of shrimp farming like feed, medicine, net, diesel etc. Hence, the distance from local market becomes an important factor.

6. **Distance from shrimp processing unit**: Shrimp processing unit is an important parameter for the purpose of site selection of shrimp farming. Shrimp heads are rapidly perishable parts of shrimp hence shrimps are needed to be made headless really fast. Other than this, the shrimp processing units have an important role in peeling, cleaning, drying, freezing and packaging of shrimp.

7. **Natural indicator** (Distance from forest): The next important factor after agricultural land is the distance of shrimp culture from the forest. In the earlier mentioned studies, it is mentioned that many forests have been degraded /destroyed in coastal areas due to shrimp farming. On the other hand, shrimp culture can be done well near the forest areas where temperature is less and level of humidity is more making it a favourable place for farming. Keeping in mind these issues, the site of shrimp culture should be selected near the forest area in such manner, that it is less harmful to the forest.

The other factors which are important for site selection of shrimp culture are availability of skilled labour, transport availability along with wait time. In this case, due to the geographical location of the five blocks of the study area, many habitants were engaged in traditional method based aqua-culture in the wetland areas or the tanks/ponds beside the river, stream, canal, along with paddy farming. For this reason, they have a basic knowledge of aquaculture. The technicians of the shrimp feed/seed supplying companies provide knowledge as well as training to the farmers for shrimp farming following scientific method. Hence, region wise variation of skilled labour cannot be identified in the case of shrimp farming. For this reason, the skilled labour is considered a constant in the present study.

The Subdivision headquarter Contai is situated in the middle position of the study area from where the travel time to the entire area is within one hour and is connected with State Highway (SH-5), National Highway (NH-116B), important metalled roads, distance from Kolkata Airport is 160 – 180 km and travel time is 3.5 to 4 hours. Therefore, in this regard, no significant variation can be noticed in the case of transport availability with respect to travel time. Apart from this, the packages are brought to the Kolkata Airport in cold storage vans for exporting the shrimp. Hence, this parameter has been considered to be constant in this study. Other than that, Forest, CRZ as well as settlement areas are also considered as constraints, therefore, not suitable for shrimp farming.

The various factors discussed here are classified into four classes according to distance and value (Table 7.1). They are given as follows

a) Most suitable
b) Moderately suitable
c) Marginally suitable
d) Presently unsuitable

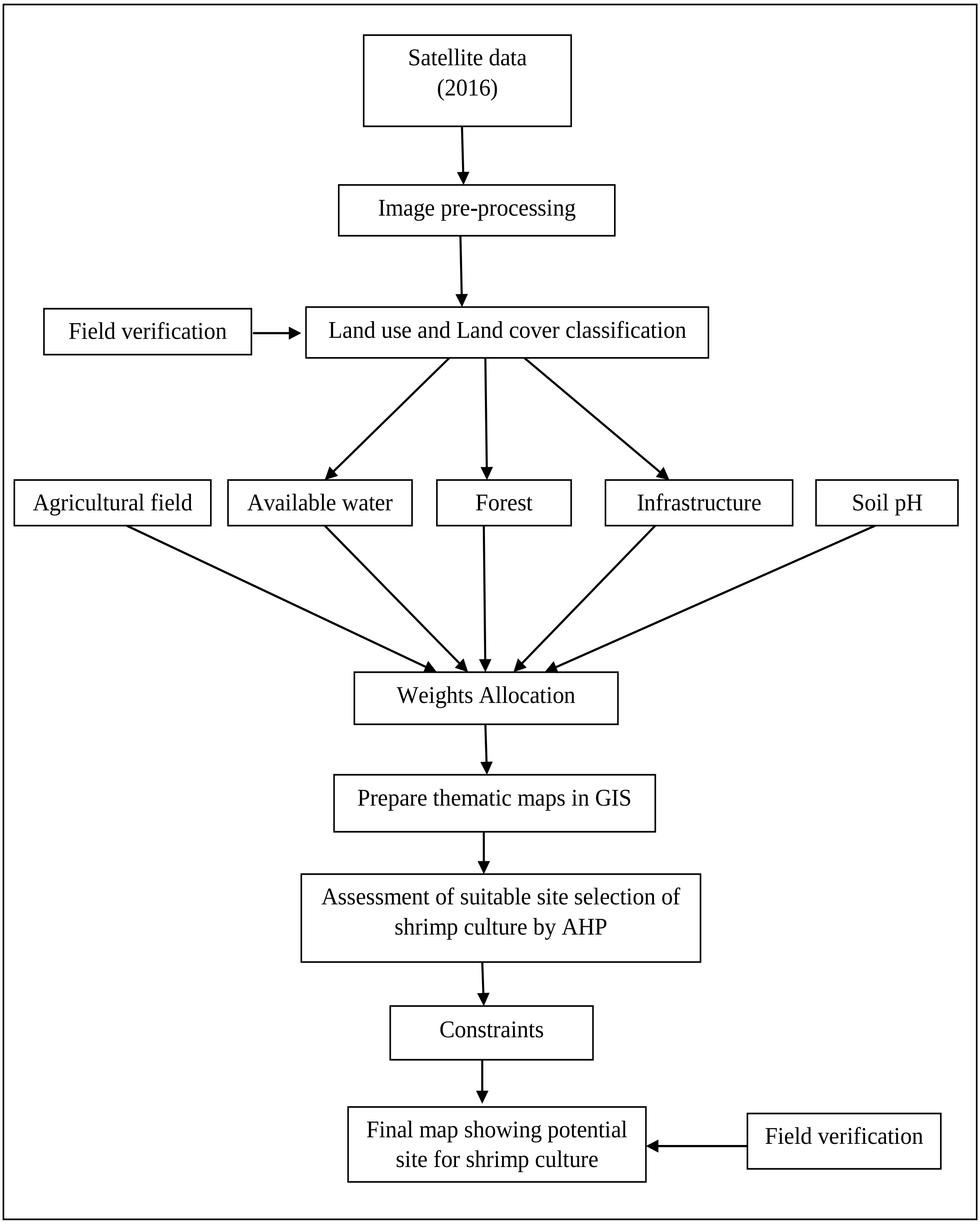



Figure 7.1 Methodology describing site suitability assessment of shrimp culture

Table 7.1 Details of criteria and constraints for shrimp culture site selection

| **Factors** | **Most suitable** | **Moderately suitable** | **Marginally suitable** | **Presently unsuitable** |
|---|---|---|---|---|
| **Available water** Distance to brackish water | 50 – 500 m | 500 – 1000m | 1000 – 2000 m | >2000 m |
| **Soil quality** Soil pH | 6.5 - 9 | 5.5 – 6.5 | 4.5 – 5.5 | <4.5 and >9 |
| **Agricultural land** Single/double crop land from distance of available brackish water | Single crop 50 – 1000 m | Single crop >1000 m | Double crop 50 – 1000 m | Double crop > 1000 m |
| **Infrastructure** Distance to road | <2000 m | 2000 – 3000 m | 3000 – 4000 m | >4000 m |
| Distance from local market | <2500 m | 2500 – 5000 m | 5000 – 7500 m | >7500 m |
| Distance from shrimp processing unit | <5000 m | 5000 – 10000 m | 10000 – 15000 m | >15000 m |
| **Natural indicator** Distance from forest | 50 – 2000 m | 2000 – 3000 m | 3000 – 4000 m | >4000 m |
| Constants | Skilled labour, Transport availability with travel time | | | |
| Constraints | Forest, CRZ and Settlement | | | |

### 7.2.1 Data sources

As the primary data source, satellite images of the year 2016 are acquired from Google Earth. Land use and Land cover of the study area was extracted from classified satellite data combined with Police Station map (scale: 1inch=1mile). With the help of the maps on soil reconnaissance survey prepared by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), soil pH values were obtained. Roads, rail lines, rivers, forest and settlement were extracted from satellite images. Crop pattern information is collected from Geoinformatics and Remote Sensing Cell, DST, Kolkata and CRZ information is collected from Institute of Environmental Studies and Wetland Management (IESWE), Kolkata. Local market and shrimp processing unit locations are collected by the field visit with the help of GPS. Different thematic layers were created based on the criteria site selection on shrimp culture (Table 7.1). Seven relevant factors for site selection for coastal aquaculture are considered in the present investigation.

### 7.2.2 Determination of weights for factors

Prior to the determination of weights for factors, a pair wise comparisons or the AHP model consisting of goal (site suitability) and factor affecting the site suitability for shrimp culture was formulated (Saaty, 1980). The site suitability for shrimp culture was placed on the top level of the hierarchy. The criteria and constraints which affect the selection of a site for shrimp culture form the second level of the hierarchy. Different classes of each criterion as well as the constraints are placed at the lower level of the hierarchy of the AHP model for site suitability analysis (Figure 7.2) Pair-wise comparison was carried out to determine the relative weight of each factor affecting the potential site selection of shrimp culture.

Details of Saaty scale used for assigning weights for different criteria are shown in Table 7.2. By following Aguilar (1996) and Kapetsky (1996), suitability rating for each criterion was established. Each factor was reclassified on a scale from 1 to 4 which are accordingly considered as very suitable, moderately suitable, marginally suitable and presently unsuitable.

Table 7.2 Details of Saaty's scale

| Factor of preference | Importance |
|---|---|
| 1 | Equally preferred |
| 2 | Equally to moderately preferred |
| 3 | Moderately preferred |
| 4 | Moderately to strongly preferred |
| 5 | Strongly preferred |
| 6 | Strongly to very strongly preferred |
| 7 | Very strongly preferred |
| 8 | Very to extremely strongly preferred |
| 9 | Extremely preferred |

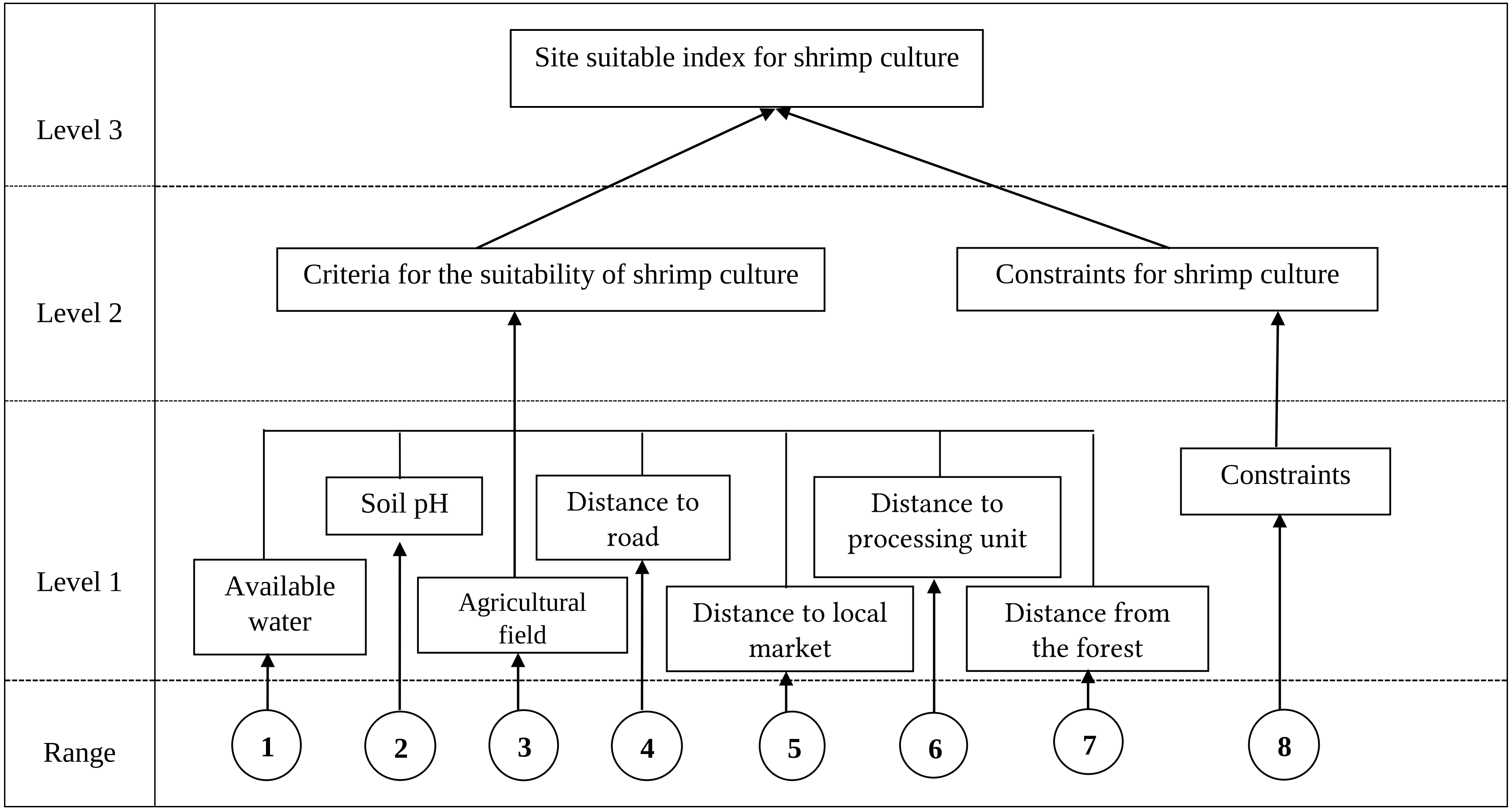



Figure 7.2 AHP model for site suitability of shrimp culture

Weights are calculated by normalizing the eigen-vector associated with the maximum eigen-value of the matrix. A consistency check was performed to validate the pair wise matrix by calculating the consistency ratio. Empirically,

$$\text{Consistency Ratio (CR)} = \frac{Consistancy\ Index\ (CI)}{Random\ Inconsistancy\ Index\ (RI)}$$

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Where, $\lambda_{max}$ = Principal Eigen-value = sum of the products between each elements of the priority vector and column total.

n = number of comparisons/criteria

If the consistency ratio (CR) > 0.10, then some pair-wise values need to be reconsidered and the process is repeated till the desired value of CR < 0.10 is reached.

Table: 7.3 Random Inconsistency Indices (RI), (source: Saaty, 1980)

| **Number of criteria(n)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Random Inconsistency Index (RI)** | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

Table 7.4 Pair-wise comparison matrix used for assessment of the relative importance of factors effecting the site selection for shrimp culture in the study area

| **Factor** | **Available water** | **Soil pH** | **Agricultural Land** | **Distance to road** | **Distance to local market** | **Distance to processing unit** | **Distance from Forest** |
|---|---|---|---|---|---|---|---|
| **Available water** | 1 | 2 | 2 | 3 | 5 | 5 | 7 |
| **Soil pH** | 1/2 | 1 | 2 | 3 | 5 | 5 | 7 |
| **Agricultural Land** | 1/2 | 1/2 | 1 | 2 | 3 | 5 | 7 |
| **Distance to road** | 1/3 | 1/3 | 1/2 | 1 | 2 | 2 | 5 |
| **Distance to local market** | 1/5 | 1/5 | 1/3 | 1/2 | 1 | 2 | 3 |
| **Distance to processing unit** | 1/5 | 1/5 | 1/5 | 1/2 | 1/2 | 1 | 3 |
| **Distance from Forest** | 1/7 | 1/7 | 1/7 | 1/5 | 1/3 | 1/3 | 1 |
| **Σ** | **2.8762** | **4.3762** | **6.1762** | **10.2000** | **16.8333** | **20.3333** | **33.0000** |

The normalized matrix (Table 7.5) acquired from pair-wise comparison matrix was used to determine the relative weight of each factor affecting the site selection.

Table 7.5 Normalized matrix of the pair-wise comparison matrix

| Factors | Available water | Soil pH | Agricultural Land | Distance to road | Distance to local market | Distance to processing unit | Distance from Forest | Priority Vector or Weight |
|---|---|---|---|---|---|---|---|---|
| Available water | 0.3477 | 0.4570 | 0.3238 | 0.2941 | 0.2970 | 0.2459 | 0.2121 | **0.3111** |
| Soil Ph | 0.1738 | 0.2285 | 0.3238 | 0.2941 | 0.2970 | 0.2459 | 0.2121 | **0.2536** |
| Agricultural Land | 0.1738 | 0.1143 | 0.1619 | 0.1961 | 0.1782 | 0.2459 | 0.2121 | **0.1832** |
| Distance to road | 0.1159 | 0.0762 | 0.0810 | 0.0980 | 0.1188 | 0.0984 | 0.1515 | **0.1057** |
| Distance to local market | 0.0695 | 0.0457 | 0.0540 | 0.0490 | 0.0594 | 0.0984 | 0.0909 | **0.0667** |
| Distance to processing unit | 0.0695 | 0.0457 | 0.0324 | 0.0490 | 0.0297 | 0.0492 | 0.0909 | **0.0523** |
| Distance from Forest | 0.0497 | 0.0326 | 0.0231 | 0.0196 | 0.0198 | 0.0164 | 0.0303 | **0.0274** |

## Calculation of Consistency Ratio (CR)

$\lambda_{max}$= (2.8762*0.3111)+(4.3762*0.2536)+(6.1762*0.1832)+(10.2000*0.1057)+ (16.8333*0.0667) + (20.3333*0.0523) + (33.0000*0.0274) = 7.3042

CI = (7.3042 - 7) / (7 - 1) = 0.0507

CR = 0.0507/1.32 = 0.0384 RI= 1.32

Normalized matrix (Table 7.5) was obtained by dividing each relative weight by the sum of relative weight in a column of the pair-wise matrix. The average value of each row of the normalized matrix (Table 7.5) yields the weight of each criterion. (Table 7.6)

Table 7.6 Relative weights for different factors

| Factors | Relative weight | % of Weight |
|---|---|---|
| Available water | 0.3111 | 31 |
| Soil pH | 0.2536 | 25 |
| Agricultural Land | 0.1832 | 18 |
| Distance to road | 0.1057 | 11 |
| Distance to local market | 0.0667 | 7 |
| Distance to processing unit | 0.0523 | 5 |
| Distance from Forest | 0.0274 | 3 |

Different thematic layers created based on the suitability for shrimp culture are shown in figure 7.3-7.12

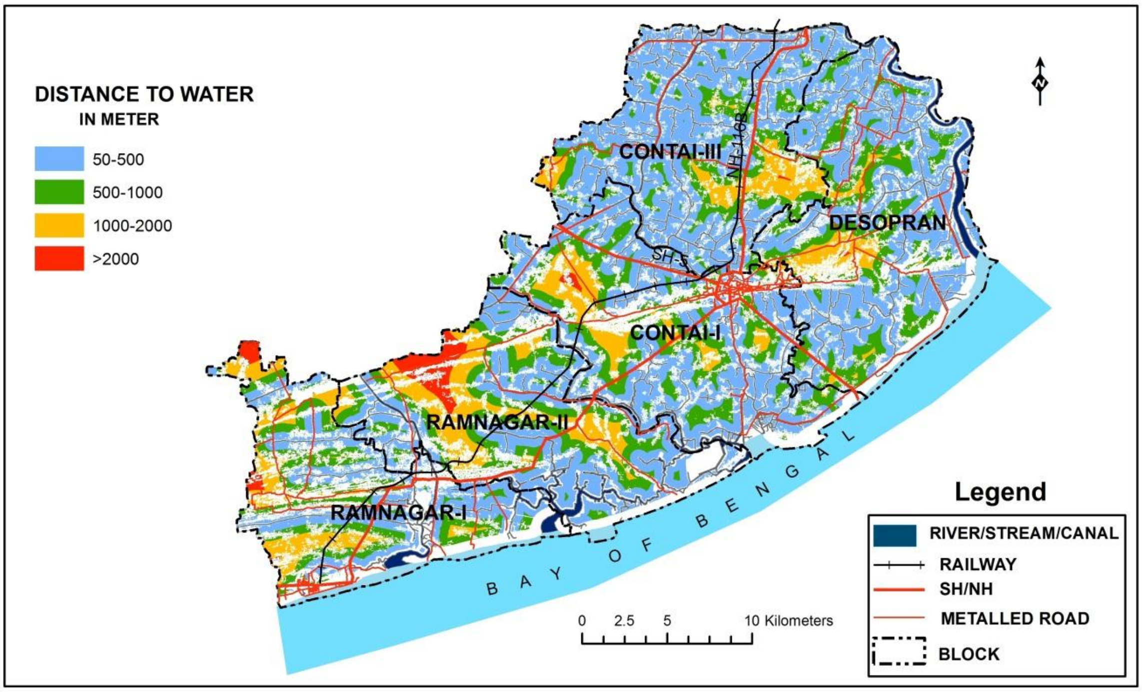



Figure 7.3 Thematic layer of available water

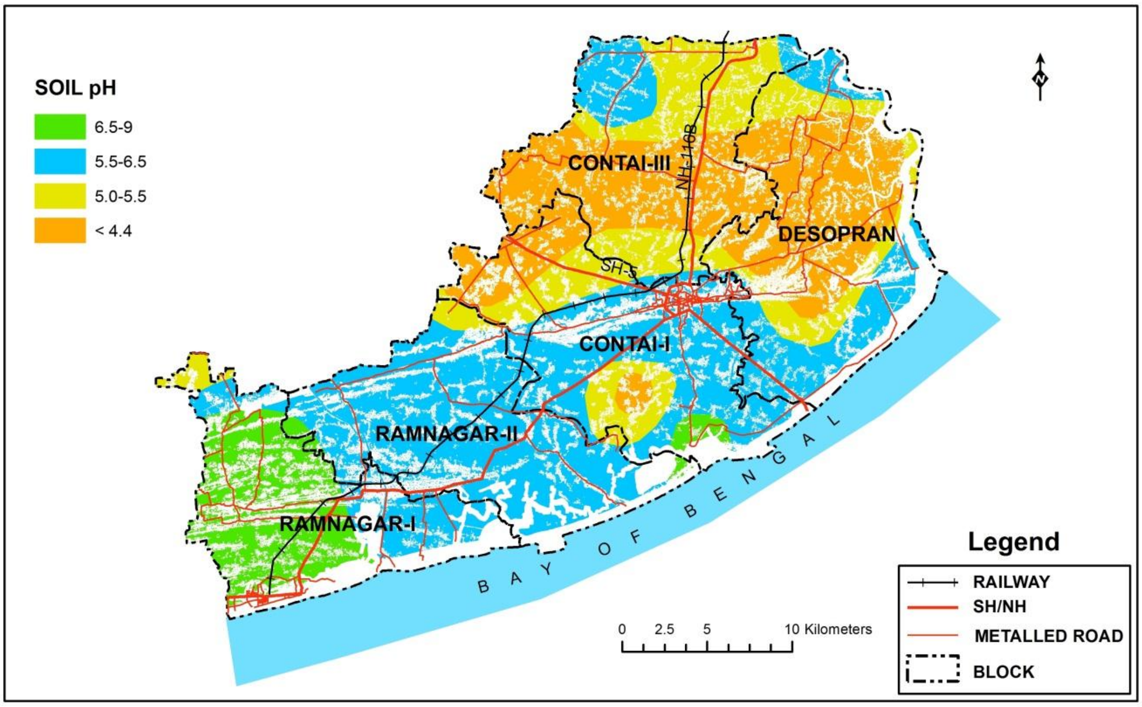



Figure 7.4 Thematic layer of soil pH

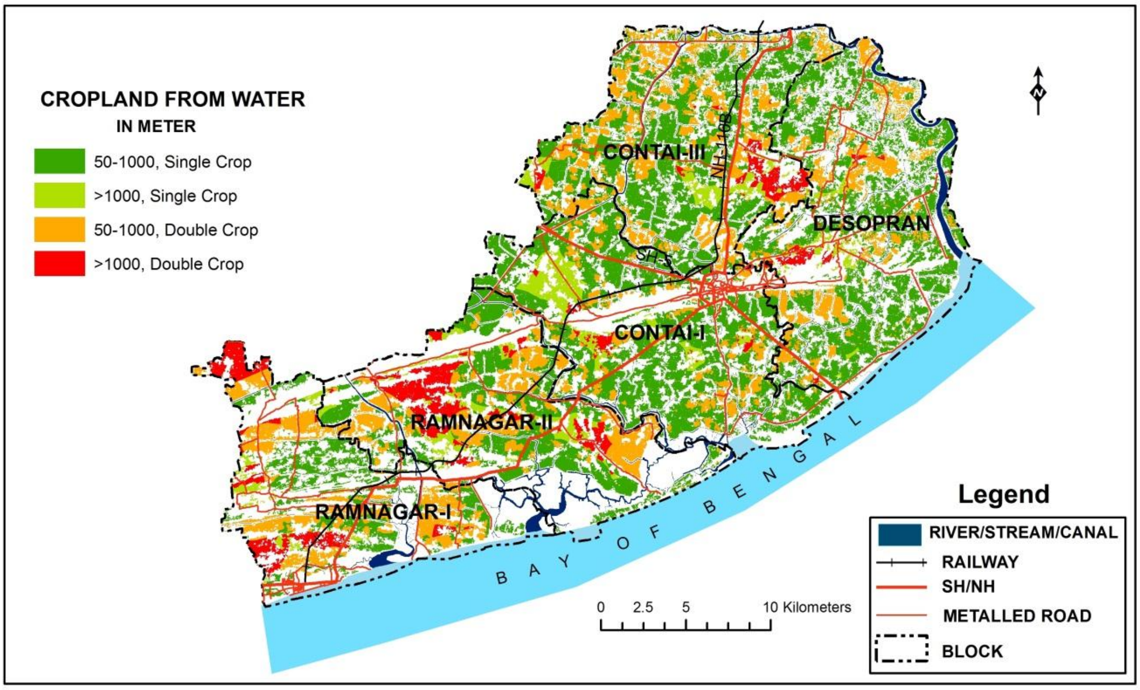



Figure 7.5 Thematic layer of agricultural land from available water

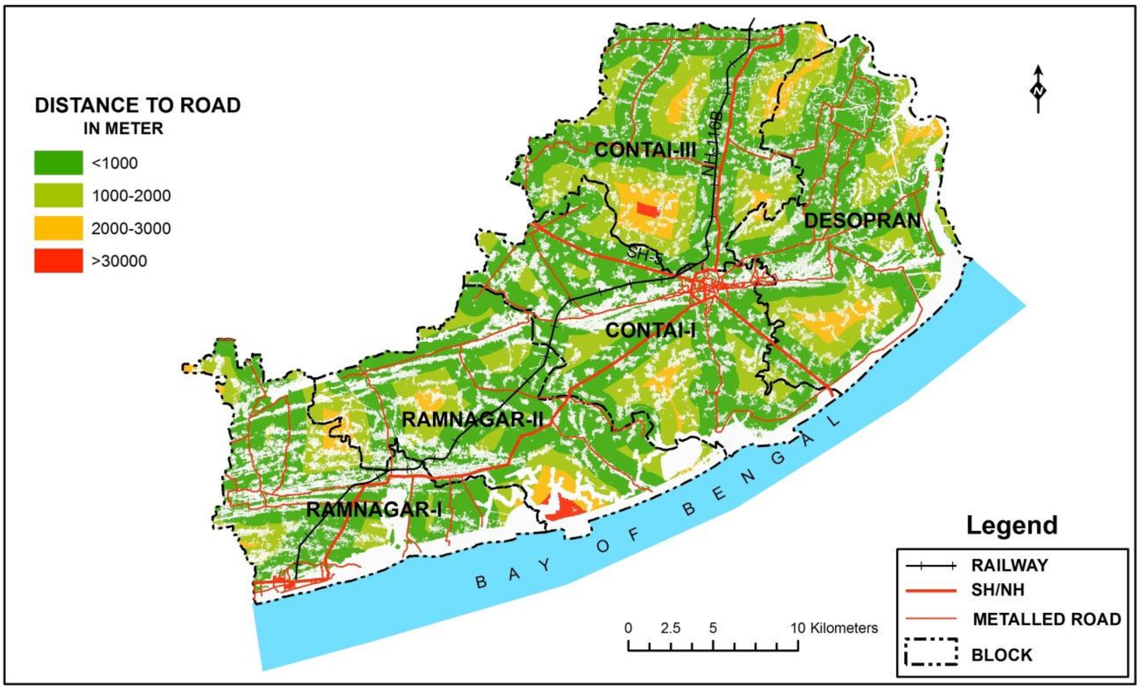



Figure 7.6 Thematic layer of distance to road

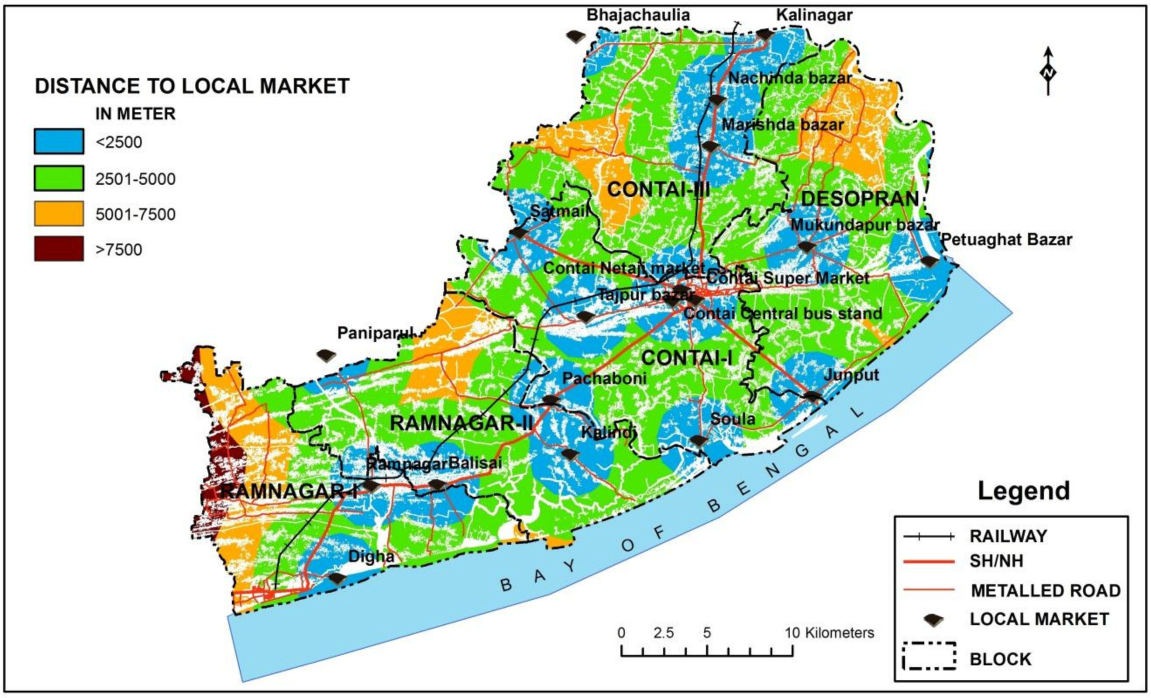



Figure 7.7 Thematic layer of distance to local market

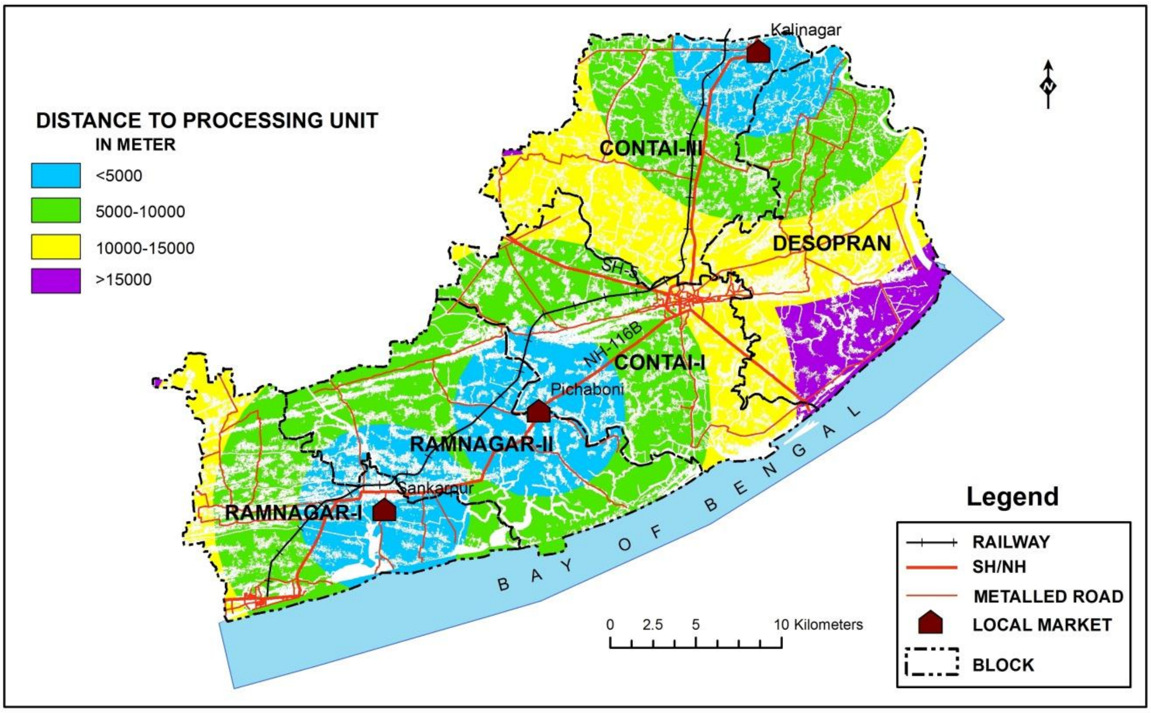



Figure 7.8 Thematic layer of distance to processing unit

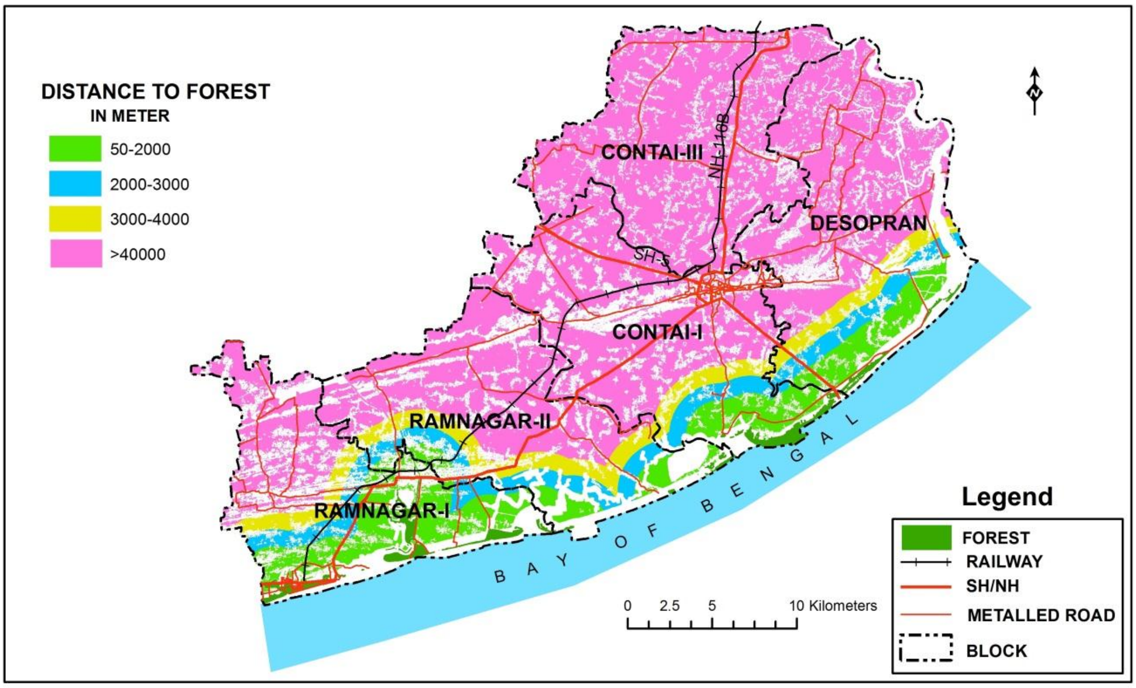



Figure 7.9 Thematic layer of distance to forest

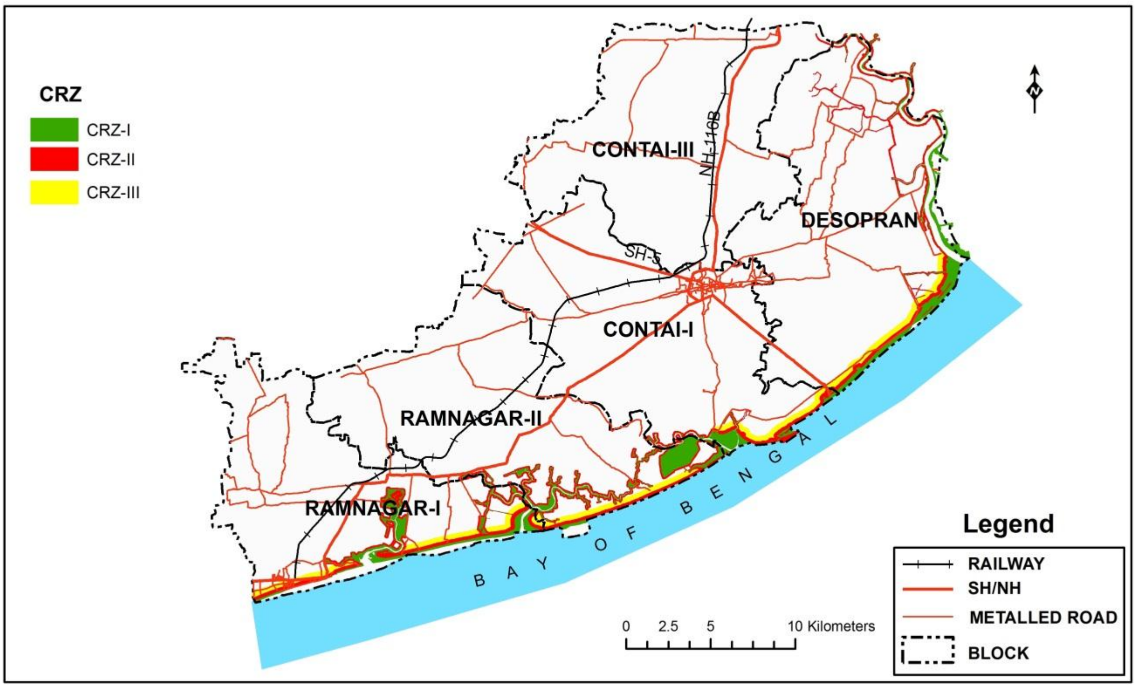



Figure 7.10 Thematic layer of coastal regulation zone

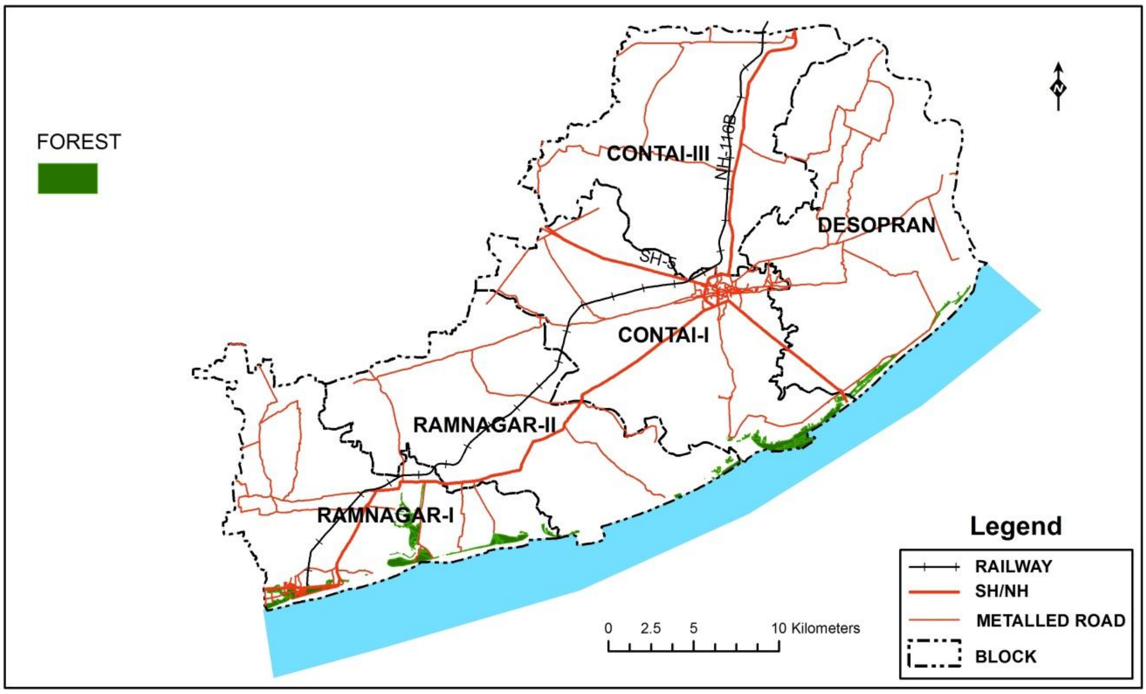



Figure 7.11 Thematic layer of forest

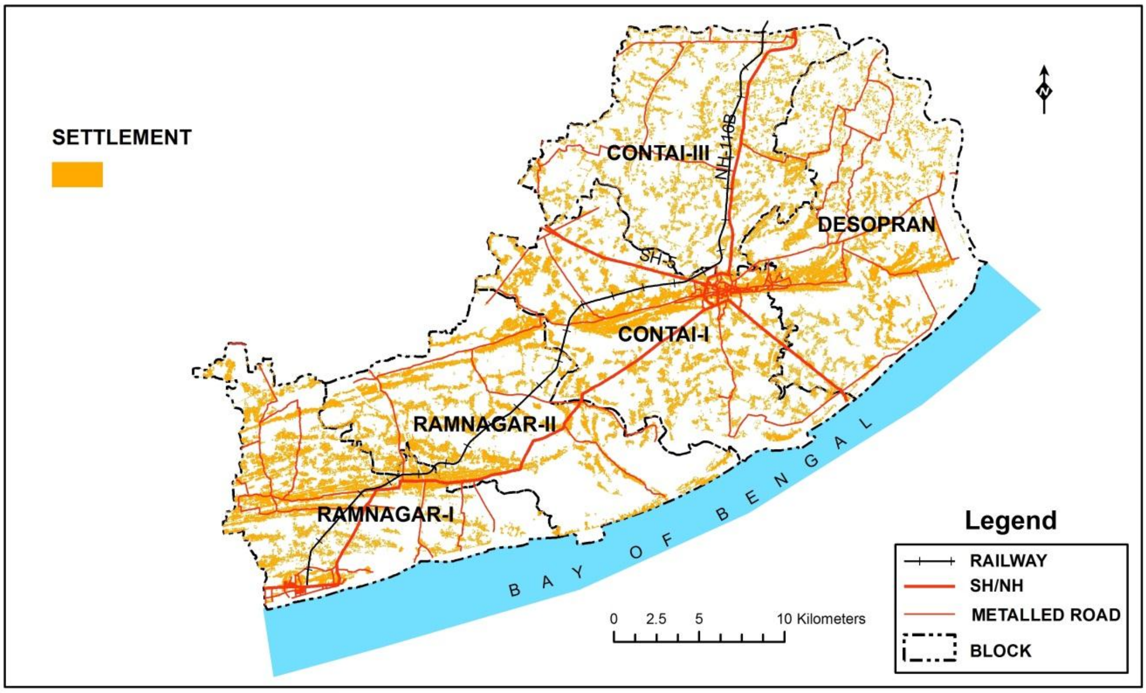



Figure 7.12 Thematic layer of settlement

It can be seen here that here, the consistency ratio (0.0384) is found to be lesser than 0.1 (Saaty, 1980). It means that the evaluation within the matrix is considerable and acceptable and shows the desired level of consistency in the comparative judgment represented in the matrix.

To distinguish the relative importance of each factor for different range (Table 7.1), a four-point scale of the score was adopted, in which four indicates most suitable, three indicates moderately suitable, two indicates marginally suitable and one indicates presently unsuitable. The multiplication of the relative weight and score of every single factor gives the total weightage for each factor. The cumulative weight for each of the seven factors was then obtained by summation of the total weight of every single factor. The cumulative weight was added up to get the total cumulative in weight for all the seven factors affecting the site suitability culture.

The major constraints for site selection for coastal aquaculture include the location of the coastal regulation zone (CRZ), protected and built-up land. The coastal regulation zone of the study area which extends 500 m from the coastal line toward side is shown in the Figure 7.10 and where the aquaculture activities are prohibited. The coverage of forests located in the study area was also created Figure 7.11 and identified as protected zones to avoid any developmental activities within the region. The Boolean nature of constraints avoids the location of the potential site for shrimp culture within the protected zones of the study area. The total cumulative weights (site suitability index) were calculated on a 0-100 scale. The study exhibits the prospects of identification as well as prioritization of the potential site for shrimp culture on the basis of the integration of Remote Sensing and GIS and analytical hierarchy approach.

## 7.3 Results

Details of areal distribution of each factor are shown in Table 7.7

The results of composite analysis of different criteria, as well as the constraints for the selection of potential site for shrimp culture, shows that 4.13% (3289.8 ha) of the total area is very suitable for shrimp culture development without any issues of land-use conflicts. The most potential area for shrimp culture is available in Desopran block which is 1175.29 ha. 6.39% of the total block area is the potential zone.

Table 7.7 Details of areal distribution of each factor for potential site selection

| Factors | Area (ha) | | | |
|---|---|---|---|---|
| | Most suitable | Moderately suitable | Marginally suitable | Presently unsuitable |
| **Available water** | 11588.81 | 5711.25 | 3179.86 | 288.44 |
| **Soil pH** | 5581.15 | 24136.94 | 10546.94 | 15004.71 |
| **Agricultural land** | 23838.70 | 2938.06 | 11483.04 | 3104.26 |
| **Distance to road** | 18152.87 | 5836.22 | 1650.87 | 528.49 |
| **Distance to local market** | 17966.37 | 31760.66 | 8309.30 | 927.81 |
| **Distance to processing unit** | 14358.90 | 25570.62 | 15840.05 | 3194.55 |
| **Distance from Forest** | 6438.18 | 1879.89 | 1644.29 | 14726.90 |

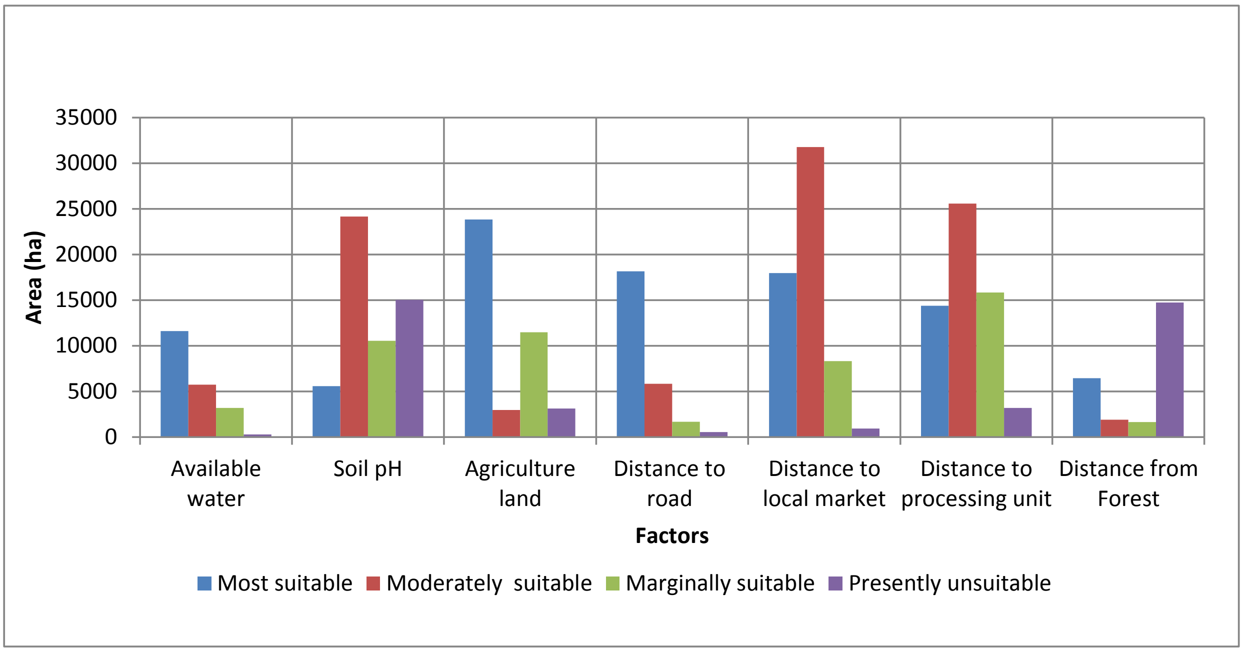



Figure 7.13 Areal distribution of each factor for potential site selection

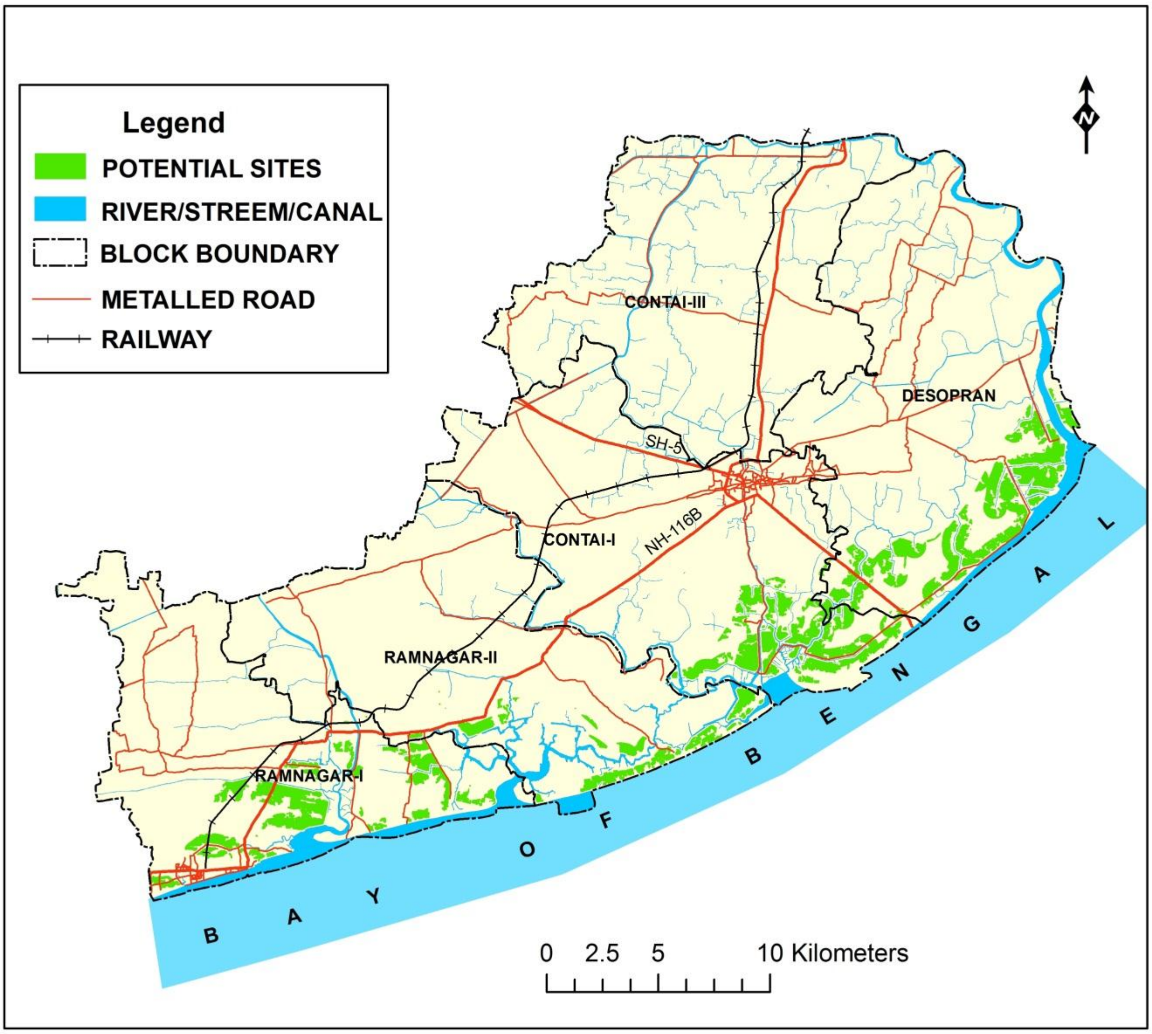
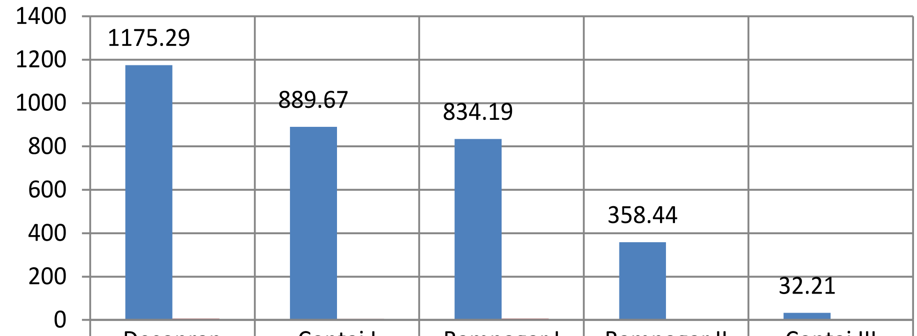



Figure 7.14 Potential sites for shrimp culture in the study area

In Contai-I the potential area is 889.67 ha (5.19%), in Ramnagar-I 834.19 ha (5.97%) and in Ramnagar-II the potential area is 358.44 ha (2.57%), whereas in Contai III it is the lowest which is 32.21 ha (0.20%) that means Contai-III block is not suitable for shrimp culture. Majilapur, Nyapur, Sabajput of Contai-I; Bamunia, Dariyapur of Desopran block, Digha, Gobra, Haldia-I, Padima-I & II, Talgachari-I & II of Ramnagar-I; Balisai, Kalindi, Satilapur of Ramnagar-II block of the study area show the high sustainable potential development of coastal shrimp culture.




| | Desopran | Contai I | Ramnagar I | Ramnagar II | Contai III |
|---|---|---|---|---|---|
| Potencial Area in ha | 1175.29 | 889.67 | 834.19 | 358.44 | 32.21 |
| % of total block area | 6.39 | 5.19 | 5.97 | 2.57 | 0.20 |

Figure 7.15 Bar graph showing block wise potential shrimp culture area

All the potential area shown are excluding of existing shrimp culture areas (Figure 7.15). This results are obtained and verified with ground truth verification. Most of the potential sites are located adjacent to the tidal creeks, river, sea, canal as it enhances the primary productivity. All the potential sides are spread over 5 km along the shoreline. But in many cases the existing shrimp farming sites are located even outside the 5 km area.

## 7.4 Summary

The potential area for sustainable development of shrimp culture is identified and prioritized based on the different criteria affecting the shrimp culture development. Analysis of data on water availability, soil quality, infrastructure facility, natural indicators and social restriction with the help of Remote Sensing and GIS technique resulted in the map showing the suitable areas for shrimp culture. Based on the study, agriculture land is found to be the most affected land use in the study area with major impact due to coastal aquaculture as well as settlement. Hence the study necessitates the sustainable development of study area by reducing the land use conflict with agriculture. Based on this, the results of the research identified and prioritized the potential sites for sustainable development of shrimp culture in these study area. The potential area for shrimp culture is estimated to be 4% (3289.8 ha) of total area by considering the aspect of the land use conflict. It is found that existing aquaculture farm is located in the unsuitable area. The study demonstrated the potential use of Remote Sensing and GIS integrated with analytical hierarchy approach to identify and prioritize the potential site for shrimp culture.