CHAPTER 5

MATERIALS AND METHODS

Impact assessment of aquaculture is the systematic identification of potential impacts of aquaculture on physical, chemical and socio economic components of the environment. Assessing existing farm design, changes in soil and water quality and changes in land use pattern due to aquaculture were the specific objectives of this study. The methodology and materials used in this study are described in the following heads of this chapter.

1. Farm design
2. Land use change detection
3. Soil characteristics.
4. Water quality

5.1 FARM DESIGN

To collect the design details of aqua farms, the format was prepared (Appendix.1). The name, location and year of starting of the farms are given in Table 5.1. Farm design details like pond slope, pond shape, main dike width and slope, secondary dike width and slope, drainage pattern and drainage canal design details, feeder channel design details, material of construction were collected and compared with standard design details. The discrepancies were listed and few remedial measures were suggested to make the farm eco-friendly.
Table 5.1 Details of the farms selected in and around the pichavaram

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the farm</th>
<th>Total area (ha)</th>
<th>Location (GPS reading)</th>
<th>Year of Starting</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>MRV farm</td>
<td>12</td>
<td>11° 25' 40&quot;N 79° 46' 36&quot; E</td>
<td>1995</td>
</tr>
<tr>
<td>3.</td>
<td>Thirumurugan farm</td>
<td>2</td>
<td>11° 25' 36&quot;N 79° 46' 23&quot; E</td>
<td>1994</td>
</tr>
<tr>
<td>6.</td>
<td>Panneer</td>
<td>5</td>
<td>11° 25' 42&quot;N 79° 46' 57&quot; E</td>
<td>1993</td>
</tr>
<tr>
<td>7.</td>
<td>Senthilvel farm</td>
<td>2</td>
<td>11° 25' 46&quot;N 79° 46' 59&quot; E</td>
<td>1994</td>
</tr>
<tr>
<td>8.</td>
<td>Venkateswara farm</td>
<td>4</td>
<td>11° 29' 12&quot;N 79° 46' 34&quot; E</td>
<td>1994</td>
</tr>
<tr>
<td>9.</td>
<td>Alzhakiri farm</td>
<td>1.5</td>
<td>11° 25' 49&quot;N 79° 47' 06&quot; E</td>
<td>1998</td>
</tr>
</tbody>
</table>

5.2 LAND USE CHANGE DETECTION

Land use change is critically linked to the intersection of natural and human influences on environmental change. The changes in the biosphere and
bio-geochemical cycles are driven by heterogeneous changes in land use and continuation of those uses (Turner, 1995). Land use planning and land management strategies hold key for development of any region. Information on existing land use, land cover, its spatial distribution and change are essential pre-requisite for planning. Inspection of a satellite image reveals information on the colour, tone, texture and pattern of different areas, which are in some way related to the underlying habitats. The changes in land use pattern was assessed by the following steps.

### 5.2.1 Preparation of Base Map

It is essential to incorporate the other related ground information on the manually interpreted map. The base map containing land water boundary, low and high water line, location of coastal villages and major towns, transport network, important cultural features, major rivers, water spread areas, reserve forest boundary and coastal bathymetry contours, was prepared using the survey of India toposheet No: 58M/11 on 1:50,000 scale. The base map was digitized in ARC INFO and topology - polygon, line and point for each category was developed. Polygon, line, and point features were labeled and the coverage was maintained separately so as to overlay in ARC VIEW and the output is shown in Figure 5.1.

### 5.2.2 Visual Interpretation

Visual interpretation is the process whereby an image is studied and habitats identified by eye. It involves overlay of base map on satellite imagery using light table and it is based on the information such as tone, texture, color, pattern, location, size, shape and association. Visual image interpretation of IRS
Figure 5.1 Base map of Pichavaram
IB, LISS II of 1994 on 1:50000 scale was carried out using the image interpretation keys given in Table 5.2. The various wetland categories like beach, mudflat, agricultural lands, mangroves, degraded mangroves, agricultural plantation and aquaculture were identified. The low water line, forest boundary and village location were transferred from the survey of India toposheet.

### Table 5.2 Image Characteristics of Coastal Wetland Classes

<table>
<thead>
<tr>
<th>Category</th>
<th>Tone</th>
<th>Texture</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estuary</td>
<td>Dark</td>
<td>Smooth</td>
<td>Semi enclosed body. Part of the lower river course that is affected by mixing of salt water with fresh water</td>
</tr>
<tr>
<td>Creek</td>
<td>Blue</td>
<td>Smooth</td>
<td>Intricate network of narrow inlets of sea water in tidal flats</td>
</tr>
<tr>
<td>Forest plantation</td>
<td>Dark red</td>
<td>Coarse</td>
<td>Slightly rough pattern</td>
</tr>
<tr>
<td>Mudflat</td>
<td>Grayish</td>
<td>Medium</td>
<td>Usually clayey &amp; silty, Vegetation may be present, Slightly rough pattern</td>
</tr>
<tr>
<td>Water Logged</td>
<td>Light to Dark blue</td>
<td>Smooth to medium</td>
<td>Dispersed, Continuous</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>Dark blue, light blue</td>
<td>Smooth</td>
<td>Slightly rough pattern</td>
</tr>
<tr>
<td>Crop land</td>
<td>Bright red</td>
<td>Medium to Smooth</td>
<td>Continuous to Non continuous pattern</td>
</tr>
<tr>
<td>Agricultural plantation</td>
<td>Dark red to red</td>
<td>Coarse to Medium</td>
<td>Dispersed, Continuous</td>
</tr>
<tr>
<td>Fallow</td>
<td>Yellow to Greenish blue</td>
<td>Medium to Smooth</td>
<td>Dispersed, Continuous</td>
</tr>
<tr>
<td>Sand/Beach</td>
<td>White/Half white</td>
<td>Fine</td>
<td>Smooth Pattern</td>
</tr>
<tr>
<td>Mangrove Dense</td>
<td>Dark red</td>
<td>Medium Coarse</td>
<td>Smooth pattern, Occurs with coastal elements categories such as mud/tidal flats, water ways, beach sand, etc</td>
</tr>
<tr>
<td>Degraded</td>
<td>Light red</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2.3 Digitization and Editing

The interpreted themes were entered into ARC INFO GIS by digitization technique. The digitization converts the spatial features on a map into digital format. Point, line and area features that compose a map were converted into x, y coordinates. The fine wire grid embedded in the tablet top digitizer was used for inputting data. After the digitization, to have a correct spatial data, the digitizing errors, label errors, node, polygons that are not closed, polygon that do not have label points or having too many label points or user ids that are not unique were corrected. The topology creation, class coding and labeling were carried out.

The maps were projected and transformed to geographic coordinates to make use the map in ARC VIEW. The final spatial information in the form of a layout with the corrected and completed maps was created using ARC VIEW.

5.2.4 Land Use Maps from Digital Data

The digital data of IRS-1C, LISS-III of 1998 and LANDSAT 5 TM of 1987 were imported to ERADAS Imagine image format. The false colour composite (FCC) of IRS 1C, LISS III 1998 and LANDSAT TM, 1987 is given in Figure 5.2 and Figure 5.3. It was enhanced using different enhancement techniques to produce a crispy image, which are available in ERADAS such as spatial, spectral, radiometric enhancements to reduce the noise, atmospheric attenuation and salt pepper effect. The image was rectified in such a manner that the spatial coordinates corresponds to its geographic coordinates. The image toposheet was resampled using cubic convolution method. The
Figure 5.2 False colour composite of LISS III, 1998 of Pichavaram
Figure 5.3 False color composite of LANDSAT, TM, 1987 of Pichavaram
projection applied was geographic Lat/Lon with Spheroid Everest and datum undefined. The methodology flow chart for land use map preparation from visually interpreted data and digital data are given in Figure 5.4 and Figure 5.5 respectively.

The digital image was registered using the resampled output toposheet to its corresponding geographic coordinates. It was resampled using Cubic Convolution method and was registered by assigning 40 ground control points approximately. Accuracy of geometrically corrected image was checked by overlaying the rectified toposheet on the digital imager and swiped vertically or horizontally to check any shift in the corresponding categories. The shifts in the image corresponding to the toposheet were again resampled with additional ground control points.

The vector layer created with the false color composite (FCC) as the background image of Pichavaram area by digitizing various features available on the imagery. The labels were assigned to each polygon for a specific land use class using vector attribute editor module. The vector layer was transferred into ARC INFO for editing and creation of topology. The vector layer was viewed into ARCVIEW and a layout was created for analysis and output generation.

5.2.5 Ground Truth Validation

Ground truth verification is one of the important components in the field of remote sensing applications. The validation of the information derived from remote sensing data was checked by ground truth information. Field checks were made in doubtful areas and the necessary corrections were made in
Figure 5.4  Flow chart for landuse map from visual interpretation and GIS
Figure 5.5 Flowchart for landuse map from digital analysis

Data Loading IRS

Enhancement of RS data for better perception

Rectification

Unsupervised classification

Grouping of classes

Area Calculation

Reference coordinates (GCPS)

Geocoding

SOI Toposheet

Ground truth

Verified information
the interpreted maps. The thematic maps were prepared in 1:50000 scale. Many of the coastal mapping projects in India follow the classification accuracy based on a sample basis, assuming a binomial distribution for the probability of success/failure of sample tests SAC (1992). Based on the ground survey, the mangrove degradation sites and aquaculture development sites were verified and the GPS measurements were taken at important places for verification.

5.2.6 Change Detection

Change detection was carried to detect any changes in land use pattern using 1987, 1994 and 1998 data. Seasonal changes under major land-use and land cover types were derived by spatial intersection of land use maps. The changes occurred from one class to other class like agriculture, mangroves etc to aquaculture were identified and the changes in area were calculated from each class to aquaculture.

5.3 SOIL CHARACTERISTICS

The soil samples were collected from nine aqua farm ponds and 0 m, 50 m, 100 m and 250 m away from the farm. The samples were air dried, powdered and sieved for further analysis at the laboratory. The following soil parameters were analyzed to assess the impact of aquaculture development soil characteristics. The properties of soil and water were statistically analysed using ANOVA and Dungan multiple test.

5.3.1 pH

Soil pH was measured as soil water pH by potentiometric method using 1:2.5 soil - water suspension (Piper, 1966).
5.3.2 Electrical Conductivity (EC)

The same soil-water suspension prepared for pH estimation was used for EC determination and it was measured by conductivity meter (Piper, 1966).

5.3.3 Organic Carbon

Organic carbon was estimated by Walkley and Black method (Chattopadhyay, 1998). It was estimated using the following formula

\[
\text{Organic carbon (\%) = \{Titration value (ml) blank - Titration value (ml) with soil\} x 0.3}
\]

5.3.4 Porosity

Bulk density was determined as ratio between weight and volume of soil and expressed in g/cm³. It refers to the mass of water free soil to its bulk volume. (Blake and Hartge, 1986a). Particle density (PD) was determined as the ratio of weight of given volume of soil solids to weight of an equal volume of distilled water in same temperature (Blake and Hartge, 1986b). It was calculated as

\[
\text{PD (g/cc) = } \frac{\rho_w (M_3 - M_1)}{(M_2-M_1)- (M_4-M_3)}
\]

Where as

- \(\rho_w\) - density of water
- \(M_1\) – Weight of empty bottle
M₂ - Weight of empty bottle and water
M₃ - Weight of empty bottle and oven dry soil
M₄ - Weight of bottle, oven dry soil and water.

The porosity was calculated from bulk and particle densities (Danielson and Sutherland, 1986)

\[
\text{Porosity (\%)} = \frac{(\text{Particle density} - \text{Bulk density}) \times 100}{\text{Particle density}}
\]

5.3.5 Water holding Capacity

Water holding capacity was determined by Keen’s box method (Piper, 1966). A weighed volume of dry soil was incubated with water and the soil along with absorbed moisture was obtained as water holding capacity of soil.

\[
\text{Water Holding Capacity (\%)} = \frac{[W₃ - (W₂ + W₄)] \times 100}{W₂ - W₁}
\]

W₁ - Weight of box + filter paper
W₂ - weight of box + filter paper + dry soil
W₃ - Weight of box + filter paper + moist soil
W₄ - Water absorbed by single filter paper.

5.3.6 Texture

Soil texture was analyzed by mechanical analysis and international pipette method
Weight of the clay and silt after 4 minutes was X g and weight of clay after 6h was Y g.

\[
\begin{align*}
\% \text{ of clay} &= Y \times 250 \\
\% \text{ of silt} &= (X-Y) \times 250 \\
\% \text{ of sand} &= 100 - (X \times 250).
\end{align*}
\]

5.4 WATER QUALITY

Water quality in aquaculture encompasses all physical, chemical and biological variables that affect aquacultural production. Water quality analysis is an important tool in aquaculture pond management, because results of analysis will indicate whether the water quality is suitable for aquacultural production or if the concentrations of certain variables are sub optimal.

The samples were collected during Sep’ 98 to Dec’ 98 and Mar’ 99 to Jun’ 99 every month in nine aqua farms in and around Pichavaram. Water samples were collected from inlet, pond and outlet of the aqua farm and also at two places from creek nearer to aquafarms in monsoon and summer seasons to find the seasonal variation in water quality. The samples were filtered through 0.45μm Millipore filter and analyzed for pH, salinity, dissolved oxygen, nitrite, nitrate, and phosphorus using the standard methods (APHA, 1995).

5.4.1 pH

pH is used to express the intensity of the acid or alkaline condition of the solution and usually determined as the negative logarithm of hydrogen ion activity. It was determined potentiometrically using the digital pH meter.
5.4.2 Salinity

Salinity varies both with the number and types of ions present in the solution, which in turn related to the concentration of ionized substances in the water. It was measured with digital EC meter.

5.4.3 Dissolved Oxygen (DO)

The dissolved oxygen was determined by Winkler's method. The samples were collected in BOD bottle and manganese sulphate, alkaline iodide reagent was added immediately after collection for preservation. Oxygen present in the sample oxidizes the divalent manganese to its higher valency after addition of sodium hydroxide and potassium iodide. Upon acidification manganese reverts to divalent state and liberates iodine from potassium iodide equivalent to DO content in the sample. The liberated iodine was titrated against sodium thiosulphate using starch as an indicator.

The amount of dissolved oxygen present in water sample was calculated using the following

\[
O_2 = \frac{CD \times M \times E \times 1000 \times 0.698 \times Vt}{Vs}
\]

Where

- \(M\) = Molarity of sodium thiosulphate
- \(E\) = Equivalent weight of oxygen
- 0.698 = to convert mg/l to ml of oxygen/litre
- \(Vt\) = Volume of thio sulphate used for titration
- \(CD\) = Correction for displacement of oxygen in the sample where oxygen is added
1000 to express per litre

\[
CD = \frac{\text{Volume of the bottle}}{(\text{Volume of bottle} - \text{Volume of reagent})}
\]

5.4.4 Nitrite

Nitrite is an intermediate product both in the oxidation of ammonia to nitrate and in the reduction of nitrate. Nitrite was determined by Diazo coupling method, through formation of a reddish purple azo – dye produced at pH 2 - 2.5 by coupling deoxidized sulfanilamide with N- ethylene diamine dihydrochloride. The absorbance was measured at 543 nm and nitrite was computed based on the following formula

\[
\text{NO}_2 \text{ (ppm)} = \frac{C_{\text{standard}} \times \text{mL}_{\text{standard}} \times (A_{\text{sample}} - A_{\text{blank}})}{\text{mL}_{\text{standard}} \times (A_{\text{standard}} - A_{\text{blank}})}
\]

5.4.5 Nitrate

Cadmium column reduction method was used for estimation of Nitrate. The nitrate was reduced to nitrite in a column containing cadmium, which has been treated with copper. The nitrate in the sample was estimated as nitrite as above after reduction.
5.4.6 Phosphorous

Phosphorous was estimated by ascorbic acid method. Ammonium molybdate and potassium antimony tartrate react with orthophosphate in acid medium to form a heteropoly acid – phosphomolybdic acid – that is reduced to intensely coloured molybdenum blue by ascorbic acid.

The absorbance was measured at 880 nm and orthophosphate was calculated as

\[
PO_4^{3-} (\text{mg/l}) = \frac{\text{Phosphate in mg x 1000}}{\text{Volume of sample}}
\]