Chapter 4

DATA AND METHODOLOGY

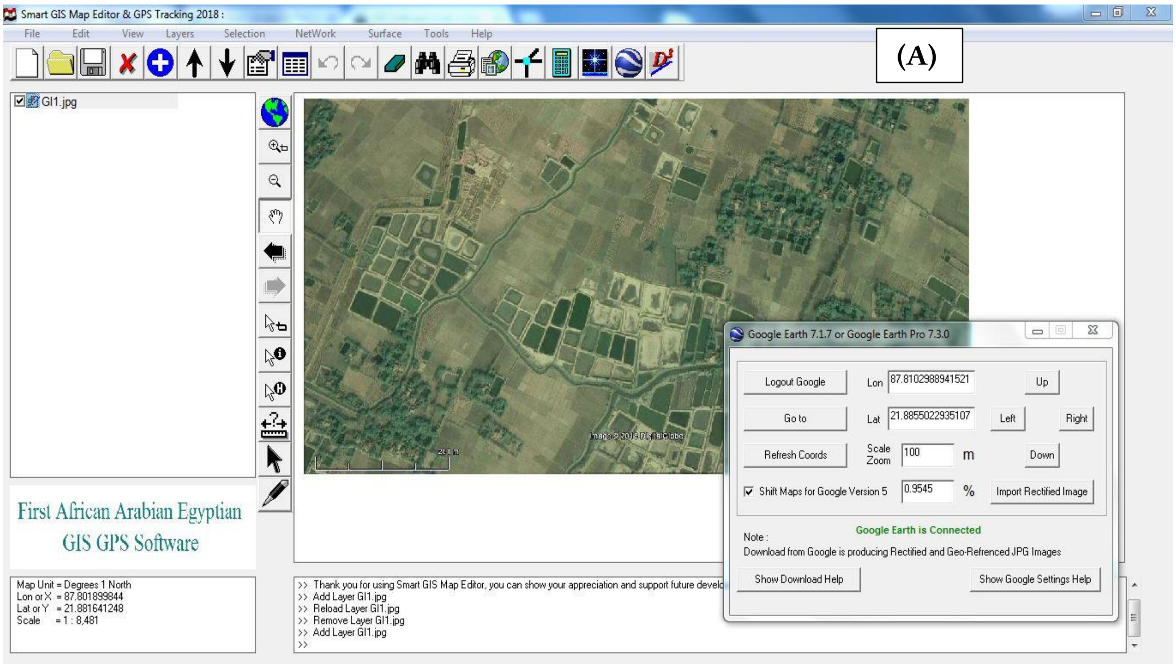
This chapter discusses the details of data used for this study. It also includes the details of the methods adopted for the current investigation. The techniques discussed in this chapter are different methods of Land use and Land cover change detection, socio-economic and environmental impact analysis and sustainable shrimp culture management.

4.1 Land use and Land cover classification and change detection

The methodology consists of pre-processing, classification of three different years' satellite data. The pixel-by-pixel comparison of two Land use and Land cover (LU and LC) has been carried out to prepare the change matrices. This change detection map has pointed to the change in the natural landscape due to human-activity.

4.1.1 Satellite data

Google Earth (GE) is one of the popular source of cloud free high resolution images. The high resolution images released from it are free and open data; provide great support for the traditional LU and LC mapping. The study area boundary is converted to GE supported format keyhole markup file (.kml) from ESRI shapefile (.shp). The corporation boundary which was digitized in ArcGIS and converted to .kml format was opened in GE. Elshayal Smart (Elshayal Smart GIS v.16.007d) which is used to extract GE images falling inside the boundary of the study area. The Elshayal smart software downloads the images (100 meters zoom scale) along with the local coordinate information, which shows the usefulness of this software in capturing images in relatively less time than require in manual operation (Figure 4.1A). Also depending on the work's need, user can adjust the scale and download the desired images. A total number of 1810 image tiles (red, green and blue bands) per year acquired in 2008, 2012 and 2016, covering the entire study area were downloaded. In Figure 4.1B the satellite image of 2016 is shown. All downloaded image tiles were mosaicked into a single image by using the ERDAS Imagine v.2011 image processing software. The years of the study are selected carefully where the major changes of the area has been shown due to shrimp farming according to the data records of DDF, Western Region, Govt. of WB.



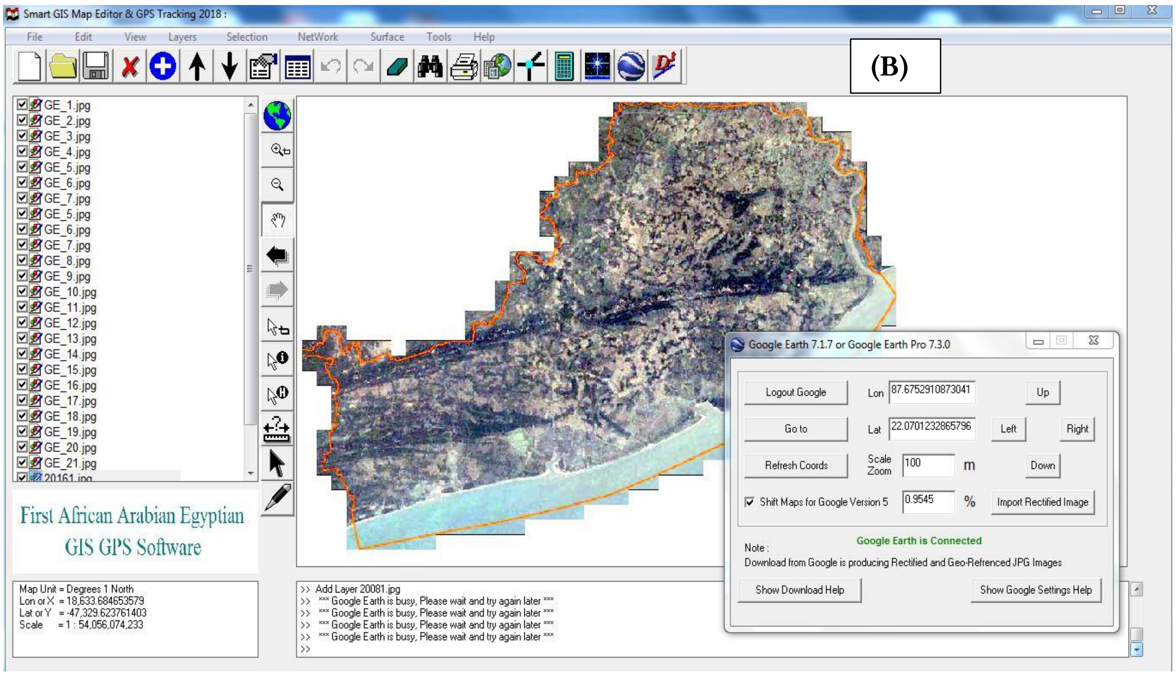


Figure 4.1 (A) Single tile of the downloaded Google Earth image, (B) Google Earth Images of the study area in the year of 2016

4.1.2 Collection and study of collateral data

For the accomplishment of this study, different spatial data of various formats were needed for specific purposes, like Survey of India (SOI) topographical map 73 O/6, 73 O/9, 73 O/10, 73 O/13, 73 O/14. Police Station (PS) maps and Mouza maps of the coastal blocks collected from Land Record Office- Kolkata. Other available information in the latest publication and map pertaining soil information and agriculture pattern, served as useful reference material for planning ground truth collection.

Table 4.1. General information of collateral datasets used in the study

Data	Source	Quality/Scale	Year
Police Station Map	DLR & S, WB	1 inch = 1mile	1927
Mouza Map (Cadastral Map)	DLR & S, WB	16 inch = 1 mile	1954-1957
Topographical Map	Survey of India	1:50000	1971,1972,1973
Census data	Census of India	Blocks/district	2011

4.1.3 Ground Control Point (GCP) collection

To show the proper Land use and Land cover distribution and change, at first it is important to geo-reference the images under study. In this reference, a few places/points should be marked which are easily accessible or reachable (for example, bridges, culverts, schools, crossings of roads etc.). For the present study, the latitude and longitude coordinates of 24 places covering the geographic area of five blocks under study were collected with the help of a handheld GPS receiver. Figure 4.2 shows the GCP locations on the geographic area.

4.1.4 Geometric correction

Raw digital images need subsequent processing to eliminate their geometric distortion. Hence, those raw images cannot be used as the base-map. These distortions result because of the variations in altitude, attitude and sensor platform's velocity etc. (Lillesand and Keifer, 2000). To compensate the distortions by these above-mentioned factors geometric correction is a prerequisite. It is employed to get the corrected image with the highest geometric integrity.

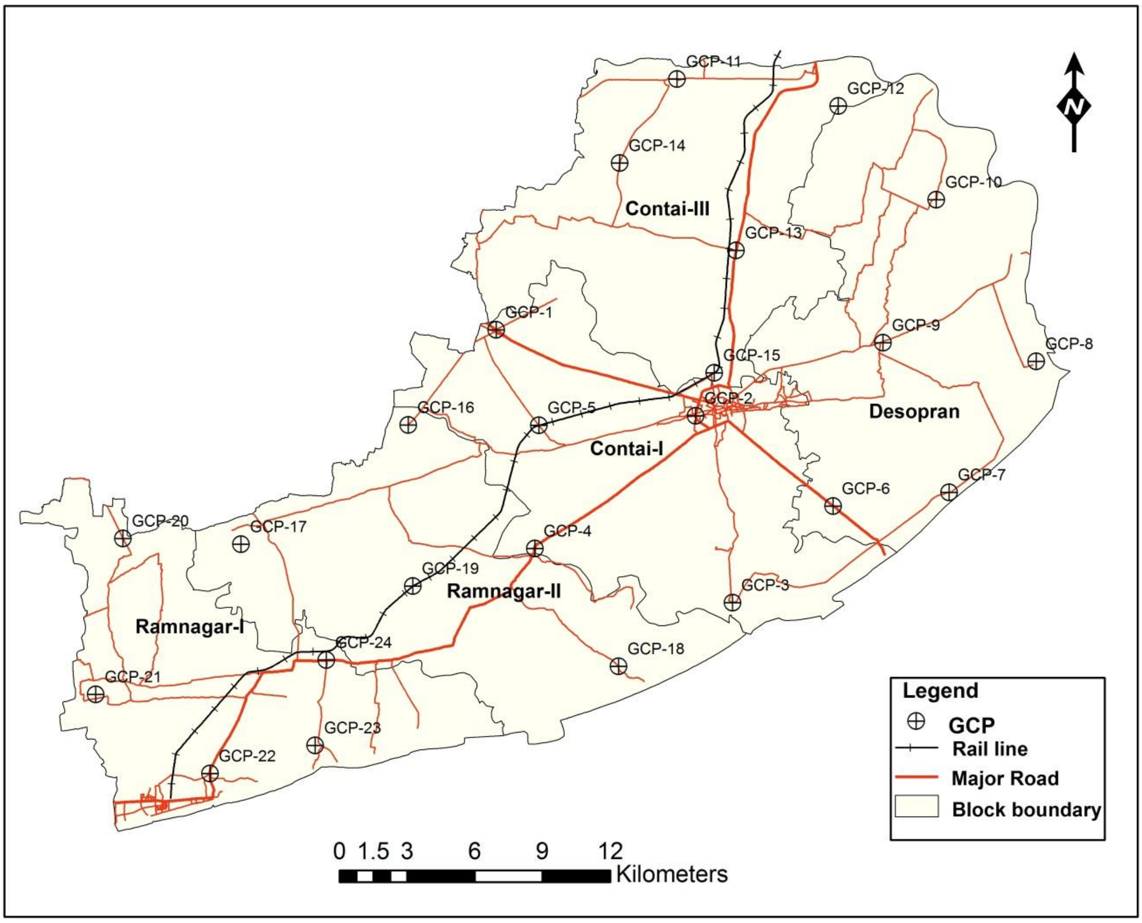


Figure 4.2 Ground Control Point (GCP) locations on the study area

The whole geo-reference phenomenon is done in two distinct steps. In the initial steps, the SOI toposheets have been geo-referenced with the help of latitude and longitude coordinates that are pointed on the grid. For this purpose, Lambert's conical conformal projection and Everest spheroid-1830 are used. The satellite images of 2008 are geo-referenced on the basis of reference SOI toposheet. Later the well-distributed GCP coordinates collected through GPS have been used to re-project the same with greater accuracy. UTM projection and WGS-84 datum have been used for reprojection. In the second step, two images of 2012 and 2016 are geo-referenced with respect to the image of 2008 by following image to image rectification process. ERDAS Imagine 2011 and ArcGIS 10 software are used for this purpose.

4.1.5 On-screen visual interpretation

Considering the importance of each class related to the present study, a total of twelve Land use and Land cover classes have been classified. All these classes are prepared by on-screen visual interpretation and digitization process. These classes are significantly separated on the basis of image elements such as shape, size, tone, shadow and location (Appendix-B). When concentrating on LU and LC variation the number of waterbodies in different years is also a considerable factor for this present study. With its quality, the on-screen digitalization has come out with an advantage over pixel-based classification and that is why considered suitable for this research. The categorization of LU and LC is done on the basis of the classification scheme of National Remote Sensing Center (NRSC) formerly known as National Remote Sensing Agency (NRSA) in the year 1995. But for the compatibility with this present research, level-II and level-III classes are modified. Following the same process, the LU and LC classification of the images for the year 2008, 2012 and 2016 has been done.

Table 4.2 Details of classification scheme (w.r.t NRSA,1995)

Level-I	**Level-II**	**Level-III**	**Acronym**
Water bodies/ Wetland	Aquaculture pond	Fresh water tanks/ponds	Fwtp
		Brackish water tanks/ponds	Bwtp
		Nayanjuli (Roadside ditch)	Nj
	Sea/River/Stream/Canal	River/Stream/Canal	W
		Sea	S
	Wetland	Waterlogged	Wl
Agricultural land	Agricultural land	Agricultural land	Ag
Forest	Plantation	Vegetation cover	Vc
	Evergreen/ Semi evergreen		
Barren/Unculturable / Wasteland	Sandy area	Sandy area	Sa
	Scrub land	Scrub land	Sl
Builtup	Rural/Urban/Industries	Settlement	Sm
		Transportation	Tp

4.1.6 Ground Truth (GT) verification

To check the accuracy of LU and LC the GT verification has unavoidable importance in this matter. During the LU and LC accuracy checking all the sixty two randomly selected places are physically verified in the year 2016 and verification of LU and LC are done for the year 2008 and 2012 consulting and discussing with the localities. After completion of the GT verification, five places are marked as mismatched (Appendix-A).

4.1.7 Mouza, Gram Panchayet (GP), Block level Land use and Land cover classification

The whole geographical study area is divided into different level of LU and LC classes such as Mouza, Gram Panchayet (GP) and Block. At present, the Mouza is the lowest administrative unit of a district. Earlier it was used as a revenue collection unit of the district. It is almost like a synonym for a gram or village. The Mouza consist of a specific area and boundary. The Gram Panchayet (GP) is actually the Village Council. According to the concept of Panchayati Raj, GP is the local self-governance system of India. GP is formed combining different Mouzas. GP also has a specific area and boundary. Similarly combing different GPs community development Blocks are formed which are also called as CD Block or Block. The Police Station (PS) maps consist detailed information of Mouzas and hence all the reference PS Maps are digitized to create vector layers with respect to the Mouzas. On addition of census data, all the Mouzas are easily distinguishable by the Gram Panchayet (GP) layer or by the blocks where they exist. The vectorized administrative layer is superimposed over LU and LC class and that's how the administrative layer wise classification of LU and LC is done.

4.1.8 Change Detection Matrix (CDM)

Change Detection Matrix is one pattern of K×K matrix, where K= No of classification categories. We can collect many different data and information from the same matrix. "From-to" information related to different LU and LC classes is available in this type of matrix. Where diagonal values represent no change data of different years, the values of rows and columns indicate different classes' data of different years, which are normally different from one another. With the help of this change detection matrix, change information and landscape transformation are done conveniently. Following is the CDM equation:

$$\text{CDM} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+}.x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+}.x_{+i})} \qquad \text{………} (4.1)$$

Where, r is the number of rows in CDM

x_{ii} denoted the number of observation in row i and column i (the major diagonal)

x_{i+} denoted the number total observation in row i (the marginal total to the right of the matrix)

x_{+i} denoted the number total observation in column i (shown as marginal total to the bottom of the matrix) and

N = total number of observations.

4.1.9 Information extract from change detection map

Change detection map is obtained by analyzing different LU and LC maps and by doing a comparative analysis of the same. To know the physical impact of the shrimp culture and to extract future reference information or data these change detection maps are studied carefully. These maps not only help to get physical data but also provide an idea about socio-economic impacts on the study area due to shrimp farming.

4.1.10 Land use and Land cover change prediction and Markov Chain

Because of the difficulties associated with deterministic models of the change process of LU and LC, it is suitable and desired to consider those as stochastic. (Lambin, 1994). The probability of LU and LC at time t_2 is derived from the knowledge of LU and LC at a time t_1. However, it does not take reference from the historical LU and LC before t_1 (Bell and Hinojosa, 1977). The stochastic processes complying this condition are defined as Markov processes. There is another term which is important in this regard is Markov Chain. It is a series of transition between certain values (i.e state of the processes.). According to Lambin, 1994 the LU and LC distribution at time t_2 is estimated from the previous LU and LC distribution at time t_1 by means of a transition matrix to model a process of LU and LC change by Markov Chain.

The Markov chain can be expressed as:

$$V_{t2} = M \times v_{t1} \qquad \text{……} (4.2)$$

Where v_{t1} = The input LU and LC distribution column vector,

v_{t2} = The output LU and LC distribution column vector and

M= m × m transition matrix for the time interval $\Delta t = t_2 - t_1$.

p_{ij} is the probability of transition between a pair of states which can easily be calculated by dividing the cell n_{ij} of the matrix by its row marginal frequency, n_i:

$$p_{ij} = \frac{n_{ij}}{n_i} \qquad \text{......... (4.3)}$$

Where, $n_i = \sum_{j=1}^{q} n_{ij}$;

n_{ij}= Number of pixels of class i from the first image that was changed to class j in the second image and

q= Total number of LU and LC classes.

If the transition probability depends only on the time interval, the Markov Chain will be stable and homogeneous in time at which the process is examined of no relevance (Karlin and Taylor, 1984).

4.2 Environmental impact study and assessment

The presence of shrimp culture is easily noticeable in coastal areas. In the same way, the impact of shrimp culture upon the physical and socio-economic environment is clearly visible. In this present study, the impact of shrimp culture upon physical and socio-economic conditions of five coastal blocks of Purba Medinipur district is shown. After analyzing the results based on shrimp culture's environmental and socio-economic impact, valuable information is extracted for the detailed evaluation of sustainable shrimp culture. With the help of the following steps impact study and assessment is done.

4.2.1 Baseline study

Baseline study usually refers to the collection of background information on the socioeconomic and environmental impacts of the shrimp farming development and it is normally one of the first activities undertaken in an Environmental Impact Assessment

(EIA). In this study, all the background information of shrimp culture were collected from the published literature, district gazetteers, census report and published map. Major land use alterations ware taken place after 2008, therefore the satellite image of 2008 and 2012 provided enormous LU and LC information of earlier days.

4.2.2 Scoping and identification of key impacts

An initial scoping of impacts identifies through 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 numerous methods for impact identification and assessment, among these “Questionnaire checklist”, “Cost Return Analysis” and “Leopold matrix” is used for this study.

4.2.2.1 Soil and water sampling and analysis

Two most important natural resources of the world are Soil and Water. Shrimp culture is fully dependent on these two resources and hence it has also a considerable impact on both of the resources. The present study has clearly explained how much influence shrimp culture actually has over these two resources. Salinity and soil pH are the most important soil parameters and impact of shrimp farming on soil is analyzed on the basis of these two. Here it is shown in two different ways- year-wise and distance wise. For distance, it is considered from shrimp ponds to nearby paddy fields. For this purpose, only those ponds are considered in which shrimp farming is done for the last five years and are surrounded by paddy fields. From a single pond site, six samples have been collected in 2012. The first sample is collected from the centre of the pond i.e at 0 m distance. All the other samples are then collected within 5 m from one another (e.g. 0m, 5m, 10m, 15m, 20m, 25m). Four sample sites are considered for each study block and therefore for five coastal blocks of study area, a total of 120 soil samples have been collected. The samples are collected after the end of shrimp culture season when all the fishes are taken out. Months from December to February are ideal for sample collection.

These soil samples are collected 30 cm (upper horizon) under the first soil layer and kept in new polybags. All the carry bags are carefully numbered with a pond id for convenience of the work. After the collection, the soil samples are dried up and dusted. To measure the soil salinity, initially, 20 gm of dry soil dust is mixed with 100 ml of distilled water in Erlenmeyer flask to make the proper solution (1:5). For a duration of 1 hour, the carefully made solution should be shaken for 30 seconds in 5 min interval. A conductivity meter is used to measure the EC solution. 25° temperature is maintained for better result. Reading has been taken in deciSiemens per meter (dS/m). Using the same technique for the prepared solution soil pH level is measured by using pH meter. EC should be measured before measuring soil pH to avoid overestimation of EC. This is because the electrode used for pH meter consists of potassium chloride which may affect the reading of EC if measured after pH. EC and pH of all the collected samples have been measured by following the same method.

These Soil tests are done in the Soil Testing Lab of Botany Department of Contai Pravat Kumar College (Figure: 4.5C-D). After 4 years, in the year 2016 same process of soil sampling has been done in the same site, following same distance intervals to take the readings, using Soil pH Tester (Figure: 4.5B). While using this Soil pH Tester some things are taken into care. The sampling holes which are created to collect the sample inside 30cm from the top layer of soil base are filled with water to make the inside soil soft and kept it for 20-30 minutes before taking the pH reading of the soil. Soil Sampling and analyzing method is done following the American Society of Agronomy (ASA) and Soil Science Society of America (SSSA).

To analyze the impact of shrimp firming over water two parameters has been considered –salinity and pH. For this, in all study blocks nine (9) water samples (per block) have been tested. Among the 9 water samples 3 samples have been collected from shrimp ponds, 3 from nearby river/stream/canal and 3 are collected from nearby tube wells. Simultaneously, salinity and pH level of neighbouring streams and tubewell of the shrimp ponds are also tested with the help of the hand held refractometer and water pH meter. For salinity handheld refractometer is used and for pH level pH meter is used for the testing (Figure: 4.5F and Figure: 4.6C). In this respect in the year 2012 total forty-five (45) numbers of samples have been tested. From June to September when it was the peak season of shrimp culture the sample readings have been taken from 9 am- 11am in the morning. After 4 years, in the year 2016, similar testing procedure has been followed to test the samples.

4.2.2.2 Questionnaire Checklist

Questionnaire Checklist method was adopted for identification of key impacts (Glasson et al. 1999). Farm to Farm survey and farmer house hold survey in fifteen 15 Mouzas (villages) surrounding the shrimp farming sites was done. A set of questions, related to the impact of the shrimp culture on the society and economy of the local people were prepared to be answered by them. Some of the questions also concerned about indirect impacts and possible mitigation measures. Few of them were associated with a scale for classifying estimated impacts, from highly adverse (-10) to highly beneficial (+10). Few samples of household survey data for socioeconomic impact assessment is presented in (Appendix-C).

4.2.2.3 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 (rice) 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 (both high scale farmers and low scale farmers). In a similar way, the data has been collected for agriculture land too. In both the cases, the cost return is calculated on one acre of area.

4.2.2.4 Leopold Matrix

The degree of impacts of the individual project action has been assessing on individual human environmental element by using the Leopold Matrix once the key impacts were short-listed. In year 1971, for US Geological Survey this matrix was developed by Leopold et al. The basis of this matrix is the horizontal lists of project actions and vertical lists of environmental components (Glasson, et al., 1999).

After a few modifications of Leopold Matrix thirteen (13) project actions, twenty-one (21) environmental components were considered in this study (Appendix-C). In each interacting cell, two numbers are recorded one is impact magnitude, from +10 (very positive) to -10 (very negative); another is significant of impact, from 10 (very significant) to 1 insignificant. The products of these two values are summed up once row-wise, and then column-wise. Row total represents the impact of all project action on individual environmental components, whereas column total represents the impact of individual project action on all environmental components. Impact on different environmental elements for individual block was assessed separately.

4.3 Identification and prioritization of potential sites for shrimp culture

The primary objective of this study is to find out the shrimp farming potential site utilizing of multi-criteria decision making analysis. Analytical hierarchy process (AHP) along with Remote Sensing and GIS was applied in this study to delineate the potential sites for shrimp farming. Analytical hierarchy process is a multi-objective, multi-criterion solution making approach in which, comparison is done in pair to arrive at a scale of preferences among the set of options. To apply this technique an unstructured complex problem is ideally required to break down into its component parts arraying these parts, or variables into structured hierarchy order, to subjective judgment assign numerical values and then synthesize the judgment to find out the variables having highest priority and should be acted on the effect of the outcome of the situation. The main steps for considering decision problems by AHP are- establishment of structured hierarchy, establishment of comparative judgment and the synthesis of priorities. All these three steps are described in the following sections.

4.3.1 Establishment of a structural hierarchy

The structural hierarchy is the prerequisite to make a complex decision based on several 'criteria'. It is structured as a hierarchical tree where the main objective sites on the top and various 'criteria', 'sub-criteria' at the bottom of the tree, and so on until the lowest level of alternative decision. In the other words, the main objective of the decision is considered at the top level of the hierarchy and the intermediate levels are represented by the decision making criteria and sub-criteria. The problem is set as a hierarchy in the initial step, the objective of the decision is the top most node and the subsequent nodes represents the criteria used to reach the decision. In the next step in between each pair of indicators the pairwise comparison are made.

4.3.2 Pair wise comparisons of criteria

Analytical hierarchy process does pair-wise comparison of the decision factors and to reflect their relative importance assigns weights. In the process, a problem is structured from primary to secondary level objective. A matrix is formed after construction of the hierarchies. In this matrix, pairwise comparison is done between the elements of the same level and between the elements of different levels. The result is clear priority statement of an individual or group. With respect to sustainable development of shrimp culture comparisons are made focusing on the importance of the two indicators i and j. The resulted matrix, *A* is a positive reciprocal matrix with dimension, where the diagonal are $a_{ii}=1$ and reciprocal property $a_{ji}=(1/\ a_{ij})$. To obtain the relative weight of the selected indicators synthesis of pair-wise comparison matrix is done in the second step. According to Saaty (1996) the best choice condition to get the excellent estimate of relative weight of the indicators is to solve the right Eigen vector of the matrix. This approach is the most appropriate approach for complex evaluation involving sustainable development. The relative importance of a pair of criteria is measured with a scale of 1 to 9. Where 9 represents greater the importance and 1 represents less importance.

Consistency Ratio (CR) is a measure to check consistency of the judgments (Atthirawong and MacCarthy, 2001). While doing pairwise comparison inconsistency is likely to occur when the decision makers make some errors or give exaggerated judgment. According to Saaty (2012) the acceptable range of consistency is less than 0.1. As a rule of thumb, if CR >0.1, re-evaluation should be done.

4.3.3 Estimation of weights

The result from a pair-wise comparison matrix is a normalized set of priority values, i.e., a set of value which offers a ranking of the options considered.

4.4 Software programs and tools used

Various types of software programs and tools have been used according to requirement of present investigation. The details of software programs and tools are discussed in the subsequent section.

4.4.1 Handheld GPS receiver

Garmin etrex-30, advanced mapping handheld GPS (Figure 4.4A) was used in this study. The major application of handheld GPS receiver in this study was GCP collection, ground-truth verification of outcome results from GIS analysis and to locate soil and water sampling sites. In this study advanced mapping GPS receiver, model Garmin etrex-30 of popular GPS receiver producing company Garmin was solely used which has an average accuracy of 3-5 m or less. The global positioning system includes a group of 24 satellites at the beginning of operation and control systems. A GPS receiver is used to determine its location anywhere on earth (Barnard, 1992). Similarly coded signals are transmitted by ground-based receivers and the satellite, so that the time delay between the receipts of signals and the emissions give the distance between the receiver and the satellite. At least three signals from three of four satellites are required to calculate the coordinates and height using triangulation method.

4.4.2 Digital conductivity meter

In the present study digital conductivity meter MK-509 model produced by iT5 company has been used to measure the salinity of soil during the study period. Digital conductivity meter is an electrical instrument which consists of an electrode inside. By putting the electrode inside of the soil-water solution (1:5) the EC is measured and from this EC value, the amount of salt present in that particular soil can be obtained. In this present study, this instrument has been used to measure the salinity of soil for the year 2012 and 2016.

4.4.3 Digital pH meter

Digital pH meter basically consists of one electrode which is inserted in a solution of soil and water at 1:5 ratio to get the values of soil pH of collected soil samples. During the study year of 2012 the digital pH meter STI-431 model manufactured by SKY Technology was used for soil pH testing of the areas under consideration (Figure 4.4E). After the study year because of the non-availability of the digital pH meter due to technical problem soil pH tester has been used.

4.4.4 Soil pH tester

As an alternate solution of digital pH meter in the year of 2016 soil pH tester has been used with accuracy of ±0.2. In this study soil pH tester of Takemura company of Japan with the model of DM-13 was used to test the pH level of shrimp pond and its neighboring rice field (Figure 4.4B). The operating temperature of the same lies between 5° C to 50° C.

4.4.5 Handheld Refractometer

Measurement of salinity was the most precise part of this study. To measure the salinity of water latest handheld Refractometer of STAC company with the model of RSH-10 ATC has been used (Figure 4.4C). This instrument was exclusively used in the study year of 2016. This is basically a precision optical instrument which can measure the salinity amount of any liquid with the help of concentration scale and refractive index. The operation is based on ATC (Automated Temperature Compensation) system. It consists of two different scales, on the right side ppt (thousandths) scale is available and the left scale is D 20/20. Measurement range of salinity 0-100 ppt, resolution 1ppt; specific gravity (D 20/20) 1.000, resolution 0.001. Accuracy level in case of salinity is ±1 and in case of specific gravity ±0.001. Automatic compensation range is 0°C to 30°C. In this study by using this instrument salinity of shrimp ponds and its neighboring streams, cannels and tube wells are measured.

4.4.6 Water pH meter

In this study Water pH meter of (PHep$^{(R)}$) HI98107 model manufactured by HANNA has been used to measure the water pH level during the ground study (Figure 4.4D). Water pH meter is widely used to measure the pH level of any waterbody. It consists of a pH probe. When the pH probe comes in contact with water, the LCD screen (which is on the upper side of the instrument) automatically displays the pH level of water. The range of this instrument lies between 0.0 to 14 pH, resolution 0.1 pH and with an accuracy of ± 0.1 pH (@25^0 C/77^{0}F).

4.4.7 Software used for GIS analysis

Various types of software have been used to analysis the different parameters of data in GIS domain. These softwares are necessary to evaluate the results of collected data.

Elshayal Smart GIS v.16.007d was used to extract the Google Earth images. ERDAS Imagine v.2011, ArcGIS v.10, QGIS desktop v.2.18.16 were used in the present investigation to carry out the various types of information and query.

It could be summarized that, the methodologies followed in this research are highly scientific and contemporary which are well accepted by the environmentalists and earth scientists worldwide. All the methodologies followed were divided into three well defined time frames, first one is pre-field literature survey, secondary data collection and data product generation; second one is the field work for GCP collection, primary survey and ground truth verification; and lastly, stands on post-field data processing and derivative map compilation. The research methods in their chronological order are illustrated by a flowchart in the next page (Figure 4.3).

METHODOLOGY

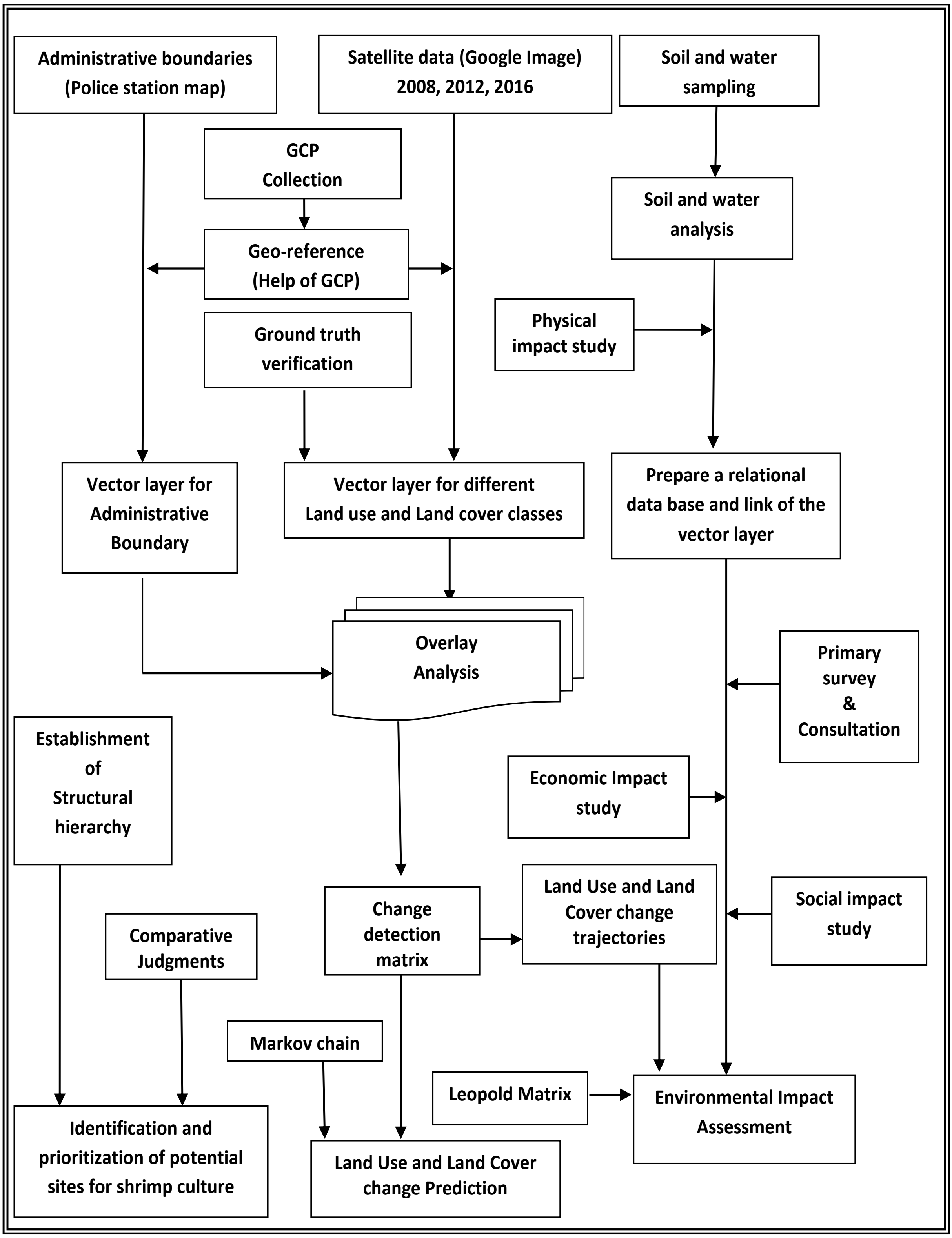


Figure 4.3 Flow chart of the methods followed

Figure 4.4 Instruments used in this study (A) Garmin GPS etrex-30, (B) Soil pH tester, (C) Hand held Refractometer, (D) Water pH meter, (E) Digital pH meter

Figure 4.5: Data collection (A) Soil sample collection w.r.t to distance from shrimp pond, (B) Soil sample collection inside the shrimp pond, (C) Testing arrangement inside the laboratory, (D) Soil pH testing (E) Measuring shrimp farming affected agriculture land (F) Water quality analysis of shrimp pond.

Figure 4.6: Data collection (A) Quality testing of ground water (B) Information collection by communicating with local shrimp farm labours. (C) Quality testing of nearest canal water. (D) Ground Truth verification.