# Chapter 3
# Methodology

## 3.1 General

Land cover change is a common phenomenon in all parts of the world. Changes in the landscape are closely linked with the issue of our natural resources such as climate, soils, water resources and biodiversity. Thus identifying and investigating the status of a resource is a crucial part in resource management and monitoring at global or local perspectives. An understanding of the landscape dynamics has great implications for land management. Knowing the landscape structure, the nature and magnitude of its changes, and how it affects landscape processes are essential in the sound management of lands and their resources. After reviewing the literatures available, a methodology to suit the objectives listed in the chapter 1 has been followed and the predictions have been made. The details of the data, methods and techniques used have been shown in the flowchart (Figure 3.1) and the explanation of the same follows below:

## 3.2 Data Used

The data needed for the study such as toposheets for the preparation of the base map and geo-referencing the maps in GIS software, Satellite imageries for the interpreting the land use categories and the details of data and mode of collection were detailed below:

### 3.2.1 Satellite Imageries

Satellite imageries for four different years (1992, 1997, 2004 and 2006) were availed from different sources and the details of the imageries used for the study were shown in the table 3.1.The interpretations of the imageries were done in the respective places of availability of the imageries.

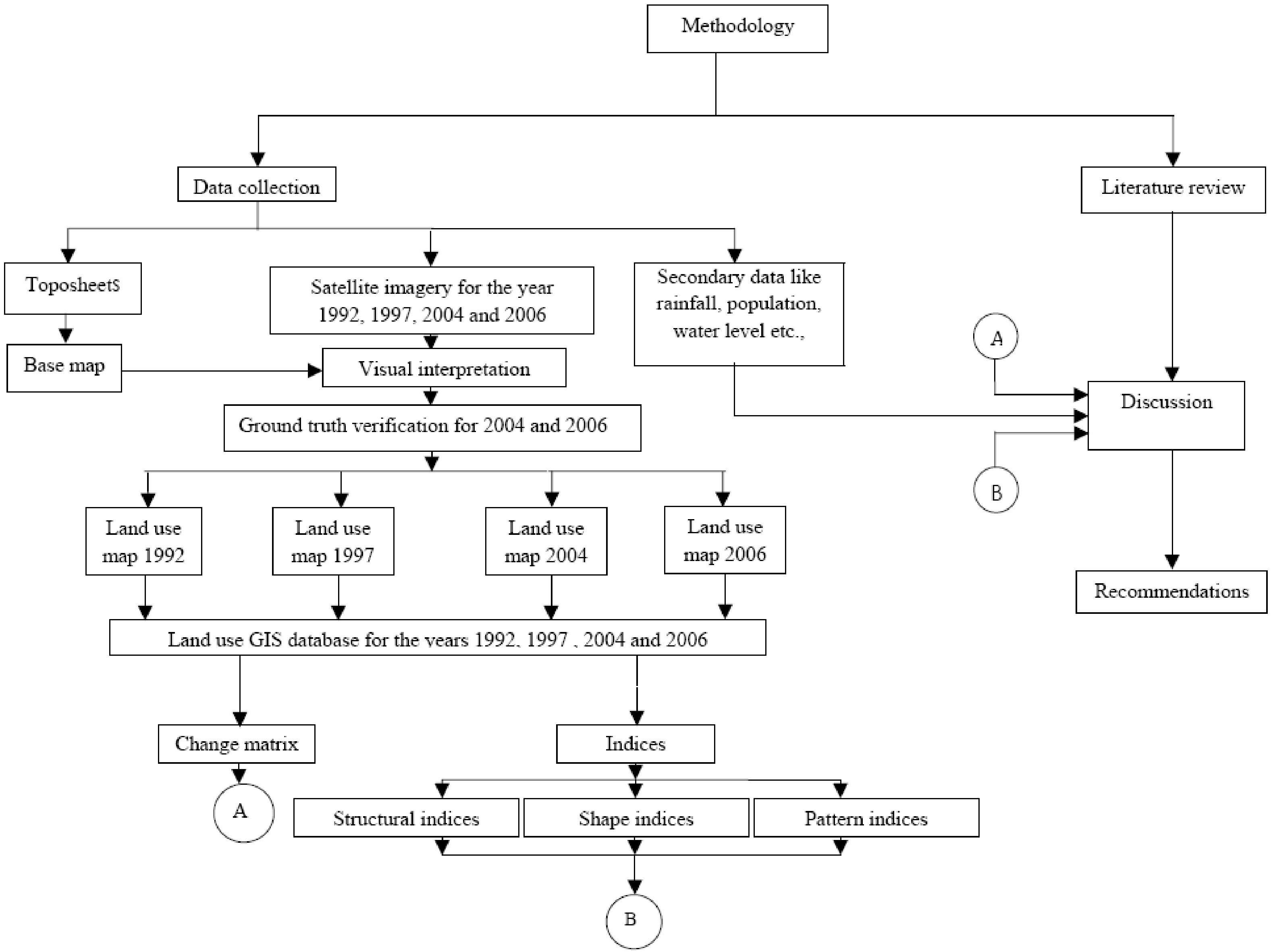


**Figure 3.1 Flow chart showing the methodology**

**Table 3.1 Details of the satellite data used for the study**

| SNo | Type of Satellite | Type of Sensor | Date of Acquisition | Scale | Remarks |
|---|---|---|---|---|---|
| 1 | IRS 1A | LISS II | 23rd March 1992 | 1:50,000 | Geocoded |
| 2 | IRS 1C | LISS III | 17th February 1997 | 1:50,000 | Geocoded |
| 3 | IRS P6<br>IRS 1D | LISS IV<br>PAN | 19th November 2004 | 1:50,000 | Merged<br>Geocoded |
| 4 | IRS P6 | LISS III | 7th April 2006 and 27th December 2006 | 1:50,000 | Geocoded |

### 3.2.2 Secondary Data

Secondary (ancillary) data constitute an important database in remote sensing, because they increase the interpretation accuracy and reliability of remotely sensed satellite data, by enabling verification of the interpreted details and by supplementing it with the information, which cannot be obtained directly on satellite imagery.

Survey of India topographical maps on 1: 50,000 scale are used in the preparation of base maps onto which the interpreted thematic details are transferred. The present study area embraces Sirkazhi and Tharangambadi taluks of Nagapattinam district. It is covered in the Survey of India toposheets of 58 / M in the scale of 1:250,000. It falls in the survey of India toposheets (58M/15 and 58M/16) prepared in the scale of 1:50,000. The toposheets used for the study were collected from the Department of Earth Sciences, Tamil University, Thanjavur.

Ground data is attributed as collection, verification and measurement of information about the different surface features on the earth, which is responsible for the occurrence of specific spectral reflectance behavioral patterns. Ground truth depends upon the extent of doubtful areas, the number of doubtful areas verified; the sampling procedure adopted during field traverses, the terrain conditions and accessibility, classification accuracy requirements etc. However collection of ground truth can be minimized with satellite data of good quality, (better contrast and cloud free), interpretation skill/experience and knowledge of the area.

## 3.3 Software Packages used

### 3.3.1 ArcMap

ArcMap is a desktop geographic information system (GIS) and mapping software. ArcMap is the module for interacting with map data. It gives the power to visualize, create, solve, present and develop spatial data. The ArcMap data frame contains geographic features such as points, lines, polygons, and raster layers. The ArcMap Editor’s integrated editing tools help in updating data with ease. ArcMap has a variety of operation modules for performing spatial analysis and manipulating data. ArcMap is used to create, edit and analyze the spatial data required for the study. The linking of spatial and non-spatial attributes is done in this software.

### 3.3.2 Geomatica

Geomatica Focus integrates PCI technologies for Remote Sensing, Image Processing, GIS/Spatial Analysis, and Map Publishing into a single integrated environment. Focus gives all of these tools in a single working and viewing environment. Tasks and processes that required more than one tool can all be done in the Focus environment. It supports geospatial data formats that include vector, raster, and ACSCII data and the Algorithm Librarian, with over 300 robust algorithms available in Geomatica Focus. The algorithm results can be displayed directly in the Focus view area, and can be saved to in storage medium. The algorithm librarian has all of the data processing functions from PCI Geomatics for Image Filtering, Data Interpolation, Image Classification, Spatial Analysis and DEM Analysis. Geomatica software is used to update the geometry of the polygons digitized using ArcMap software.

## 3.4 Methodology

### 3.4.1 Preparation of Land Use map

Land use refers to "man's activities and the various uses which are carried on land". Land cover refers to, "natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation". Although land use is generally inferred based on the cover, yet both the terms land use and land cover being closely related are interchangeable. For example, vegetation as a cover for agricultural crop and for forest and the respective activity is classified based on the contextual evidence.

The land use maps of the study area for the years 1992, 1997 and 2004 are prepared using the satellite imageries through the process of visual interpretation. The methodology is based on monoscopic visual interpretation of IRS imagery using National Remote Sensing Agency classification system (Anon, 1989). The interpreted details are to be ground checked to verify the doubtful areas. Based on the ground verification, the boundaries of the different land use/land cover unit are to be finalized. The corrected details are to be transferred to the single base map on 1:50,000 scale.

### 3.4.2 Image Interpretation

Image interpretation is defined as the art of examining images for the purpose of identifying objects or surface features and judging their significance. Interpreters study remotely sensed data and attempt through logical processes in detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationships. Image interpretation of remotely sensed data can be attempted either by visual or digital techniques of analysis. The purpose of applying either of the above two techniques is for feature identification and classification.

Image interpretation is a complex process of physical, psychological activities occurring in a sequence of time. The sequence begins with the detection and identification of images and later by their measurements. Images are then considered in terms of information, usually non – pictorial and finally deductions are made. The various aspects image interpretation as described by Vink (1964) is listed below in a simpler form. Most of these have overlapping functions.

#### 3.4.2.1 Detection

It is a process of picking out an object or element from the photo or image through interpretation techniques. It may be detection of point or line location. Example: agricultural fields or buildings/small settlements.

#### 3.4.2.2 Recognition and identification

It is a process of classification or trying to distinguish and object by its characteristics or patterns, which are familiar on the image. It precedes the process of detection. Sometimes it is also termed as photo reading. Example: Water features: stream, canal, tank and sand.

#### 3.4.2.2 Analysis

It is a process or separating a set of objects or features having similar set of characteristics. In analysis lines of separation are drawn between groups of objects and the degree of reliability of these lines can also be indicated. Example: Sands as that of river, desert and coastal.

**3.4.2.4 Classification**

It is a process of identification and grouping of objects or features resolved by analysis. It arranges features of recurrence in the same class or group to which the feature belongs. Any wrong identification and analysis may often lead to misclassification.

**3.4.2.5 Deduction**

Deduction may be directed to the separation of different groups of objects or elements and deducing their significance based on covering evidence. The evidence is derived from mainly visible objects or from invisible elements, which give only partial information on the nature of certain correlative indications. Deducing in regard to the identity of objects made without proper pre-interpretation checks in the field, may often be misleading and result in wrong classification. For complicated interpretation, therefore, it is advisable to effect the separation under this process and leave the deduction of the identity till after the classification.

**3.4.2.6 Idealization**

It is a process of drawing ideal or standard representation from what is actually identified and interpreted from the image or map .Example: a set of symbols or colours to be adopted in land use maps or an ideal example on ravines. This process helps in developing the image interpretation key.

**3.4.3 Elements of image characteristics**

There are certain fundamental photo-elements or image characteristics seen on image which aid in visual interpretation of satellite imagery. Although, there is a difference of opinion on the number of elements to be included, there is however a general consensus on the following:

#### 3.4.3.1 Tone / Colour

Different surface objects reflect and emit different amounts or radiant energy. These differences are recorded as tonal/colour or density variations on the imagery. In black and white images, objects appear in different gray tones. These gray tones often fail to provide the interpreter clear perception of objects. Whereas, true colour or false colour imagery increase the interpretability be providing a subtle tonal contrast between them. Tonal contrast can be enhanced or reduced either optically or by enhancement techniques using computers.

#### 3.4.3.2 Size

It refers to the spatial dimension of the object on ground. Size of an object is a function of scale of the image or photo and is also measurable. These are different objects with varying sizes and shapes. Example: Gullies – varying size and depth; sandy areas – large and extensive; jhum areas – small in extent.

#### 3.4.3.3 Shape

It refers to the physical from of an object and is also a function of scale of the image or photo. Size and shape are interrelated. In the image, shape refers to plan or top view of the object, seen by the satellite. Shape can be irregular. Example: Salt affected patches; boundary of undulating uplands; or regular and uniform. Example: Snow of glacier.

#### 3.4.3.4 Texture

It is defines as a repetition of basic pattern. Texture in the image is due to tonal repetitions in a group of objects which are often too small to be discernible. It creates a visual impression of surface roughness or smoothness of objects and is a useful photo element in image interpretation. Example: salt affected land – fine to mottle; rocky areas – coarse.

**3.4.3.5 Pattern**

It refers to the spatial arrangements of surface features, which are characteristic of both natural and man – made objects. Similar features under similar environmental conditions reflect similar patterns of recurrence. Example: Salt affected land in irrigated areas and gullies in eroded areas. Pattern is of several types. Example: linear - road, rail, canal; non – linear – streams, creeks; contiguous – snow, sand; clustered – settlements; dispersed – forest blanks, salt affected patches; regular – orchards, linear cropping etc. More often patterns also reflect associations. Example: intensity of drainage patterns shows it relation with rock types, soil texture, rainfall, run –off etc.

**3.4.3.6 Location**

The geographical site and location of the objects often provide the clue for identifying objects and understanding their genesis. Example: salt affected land, Inland River, desert plains; jhum or forest blanks – hill slopes; snow or glacier – mountain peaks etc.

**3.4.3.7 Association**

It refers to the situation of the object with respect to other surface features and neighboring features. Example: canals with agricultural fields; marsh or swamps with flood plains and tidal flats; gullies or ravines with severely eroded lands.

#### 3.4.3.8 Shadow

They are cast due to sun's illumination angle, size and shape of the object or sensor-viewing angle. The shape and profile of shadows help in identifying different surface objects. Example: clouds, nature of hill slopes, aspect, apparent relief, etc. They also help in arriving at tree heights or hill/building heights on aerial photos.

#### 3.4.3.9 Resolution

It is of two types, spatial and spectral. The former refers to 'picture element' or pixel discernible on the image of the smallest area resolvable or identifiable on ground. Spatial resolution allows the interpreter to detect and distinguish the smallest object on the ground.

#### 3.4.3.10 Aspect

It refers to the direction in which a mountain/hill slope faces particularly with reference to possible amounts of sunshine and shadow. Aspect has marked effects on the sitting of vegetation, settlements and cultivation.

After interpreting the land use details of the study area for three different years as categorized in table 3.2, the accuracy of the interpretation of the year 2004 land use map was checked by ground truth information.

### 3.4.4 Creation of Land use spatial database using GIS

The land use maps interpreted in hard copy form for different years followed by ground truth information of the year 2004 were scanned in tiff format and inputted in the ArcMap module of ArcGIS software. Six tic points were selected for all the maps and were geo-referenced using ArcMap. The accuracy was checked with more tic points. A different shape file was created for each map and the maps were digitized as shape files with polygon mode available in the ArcMap so as area changes can easily be estimated. The shape files were then converted into coverages using ArcTool box. The tables of the coverages were updated with the categories of the interpreted land use. Since the projection system was not defined in the ArcMap software, the area of the polygons was got in decimal units and this cannot be converted into square units. So Geomatica software was used to get the area of the themes in square meters using update geometry option available in the software. Then layout was prepared for the land use of different years of the study area using ArcMap.

### 3.4.5 Land use change detection

The spatial data base land use created for the study area for years 1992, 1997 and 2004 were subjected to intersection analysis available in Geoprocessing Wizard of ArcMap. When using the GeoProcessing Wizard, analysis will be run for more than one layer. These layers may reference data sources defined by different coordinate systems. For best results, all the layers in the analysis should be projected with the same coordinate system. However, there may be instances when the layers have different coordinate systems. In those cases, the output from a GeoProcessing operation will be in the same coordinate system as the data frame. The GeoProcessing Wizard allows the users to combine layers in different ways based on the geography of the features in the layers. The GeoProcessing Wizard lets us with the following:

- Aggregate features in a single layer that have the same attribute value (dissolve).
- Append two or more adjacent layers into a single layer (merge).
- Reduce the spatial extent of one layer based on the extent of another (clip).

- Find those features falling within the spatial extent common to two layers (intersect).
- Combine two polygon layers (union).

The intersection analysis was done using the intersect option of the wizard. Intersect is used when a layer is overlaid with the polygons in another layer so that the resulting output layer a) has the combined attribute data of the features in the two inputs, and b) only contains features that fall within the spatial extent of the overlay polygons. In this way, we can find just those features that overlap and 'stamp' the attributes of the overlay polygons in the second layer onto the features in the first layer.

Then the resulting table was saved in the form of Excel table so as the table may be supported in Microsoft Excel. The land use change matrix for the three different years was derived using Microsoft Excel.

### 3.4.6 Indices and Measures of Landscape pattern

Landscape indices broadly fall into one of two categories: non-spatial and spatial (Gustafson 1998). Non-spatial indices describe landscape composition and include measurements of the number of patch classes composition, shape and configuration. In the strictest sense, only patch composition relates to fragmentation, but the traditional view of ecosystem fragmentation encompasses all three (as well as loss of area or proportions of total area. Spatial indices describe patch attributes and contain information relevant to measuring fragmentation. The spatial indices can be further divided into those that describe patch). The various landscape indices are grouped into three classes such as structural, shape and pattern indices. The various indices mostly needed to quantify changes in spatial and temporal pattern of the land use are estimated as follows (Zhou Zaizhi, 1999):

### 3.4.6.1 Structural Indices

Structural metrics can be defined as those that measure the physical composition or configuration of the patch mosaic without explicit reference to an ecological process. Structural indices describe the basic characteristics of fragmentation. The two basic indices used to quantify fragmentation are number of patches and patch area, usually measured as mean patch area. However, they provide an incomplete picture because the fragmentation concept also encompasses the relative sizes of the pieces that result. Also, mean patch size is sensitive to the addition or deletion of small patches. As a result, the largest patch index, which measures the largest patch of a given class as a percentage of the total landscape, is used to indicate relative size (With and King, 1999; Saura and Martinez- Millan, 2001). These measures are affected by the resolution (Benson and Mackenzie, 1995) and extent of the study area. The following are the structural indices considered for the study:

N = Number of patches of each land use type.

P = Proportion of each land use type.

S = Total area of each land use type.

S1, S2, S3 = Mean, maximum and minimum area of patch in one land use type.

### 3.4.6.2 Shape Index

Shape indices attempt to quantify patch complexity, which can be important for different ecological processes (Forman 1995). For example, circles or squares will have less edge and, potentially, more core area. Other shapes such as long, narrow features like tree lines or sinuous features like riparian areas may have comparatively little core area despite a large total area. Compact areas may be less visible to species dispersing across the landscape, while convoluted or linear shapes may intercept the paths of more organisms or propagules (Forman 1995). The index commonly used to characterise shape is fractal dimension (Krummel et al. 1987; O.Neill, et al. 1988; Milne, 1991). Fractal dimension measures the degree of shape complexity. Fractal dimension varies theoretically from 1, which indicates relatively simple shapes such as squares, to 2, which indicates more complex and convoluted shapes. The methods for calculating fractal dimension vary depending upon the question or application. For landscape analysis, a common method involves regressing the patch perimeters versus patch areas on a log-log scale and relating the fractal dimension to the slope of the regression (McCarigal and Marks 1995). The fractal dimension of the patch perimeters is equal to twice the slope of the regression line (Gardner et al., 1987; Burrough, 1986).

#### 3.4.6.3 Pattern Indices

Pattern-based indices of configuration attempt to provide a measure of the overall complexity of the landscape in question. Unlike distance measures, they do not have a patch focus and are calculated using the entire landscape. The pattern indices used for the study are landscape diversity index and landscape dominance index. The Landscape Diversity Index quantifies the diversity of the countryside based on two components: the number of different patch types and the proportional area distribution among patch types. It depends on the number of patches and harmonious proportion of the land use type, has impacts on the species and genetic diversity and finally affects the stability and productivity of the system. Dominance is a measure of dominance in a landscape indicating the deviation from the maximum possible landscape diversity. Large dominance value indicates that the area is dominated by a few land use types, while a lower value indicates more equal distribution of land use types. The indices are estimated as follows (Shannon and Weaver, 1962):

$$H = -\sum_{i=1}^{m} P_i \log(P_i) \text{ ------------------------------------------------------- } (3.1)$$

Where,

H = Landscape diversity index

$P_i$ is the proportion of land use type i and m, the number of land use types.

$$D = H_{max} + \sum_{i=1}^{m} P_i \log(P_i) \text{ ---------------------------------------------------- } (3.2)$$

D= landscape dominance index.

$H_{max}$= log (m), the maximum diversity when all land use types were in equal proportion

**Table 3.2 Land Use categories according to NRSA Classification**

| SNo. | Level I class | Level II class |
|---|---|---|
| 1) | Built up land | 1.1 Built up land |
| 2) | Agricultural land | 2.1 Crop land<br>2.1.1 Kharif<br>2.1.2 Rabi<br>2.1.3 Double crop (Kharif + Rabi )<br>2.2 Fallow<br>2.3 Plantation |
| 3) | Forest land | 3.1 Evergreen / Semi- Evergreen<br>3.2 Deciduous<br>3.3 Degraded<br>3.4 Forest blank<br>3.5 Forest plantation<br>3.6 Mangrove |
| 4) | Waste land | 4.1 Salt affected land<br>4.2 Water logged land<br>4.3 Gullied/Ravenous land<br>4.4 Marsh / Swampy land<br>4.5 Land with / without scrub<br>4.6 Sandy area – Inland / coastal<br>4.7 Barren rocky / storm waste / sheet rock |
| 5) | Water bodies | 5.1 River / stream<br>5.2 Lake / reservoir / tank / canal |
| 6) | Others | 6.1 Shifting cultivation<br>6.2 Grass land / grazing land<br>6.3 Snow covered / glacial area<br>6.4 Salt pan<br>6.5 Mining area |