CHAPTER I

PROBLEM AND PROCEDURE

1.1 INTRODUCTION

Agricultural resources are considered to be one of the most important renewable and dynamic natural resources. Comprehensive, reliable and timely information on agricultural resources is very much necessary for a country like India, where agriculture is the mainstay of our national economy. But it is being pressurized by high population growth and natural hazards like flood, drought, and cyclone and soil erosion. As a result, the productivity of the land is declining and the country cannot produce as much food as needed for the increasing population.

Though India made several achievements in agriculture, still there is a need to make use of the land in the most rational and possible way. In this sense, Geographical Information System (GIS) and Remote Sensing (RS) technology offers a dynamic tool for multidimensional process of land use. Remote sensing (RS) provides landscape information synoptically, repetitively and objectively. It is an important source of spatial information such as land use/land cover, drainage and topography. GIS is a powerful tool for geo-environmental analysis and appraisal of natural resources. It allows the user to integrate data bases generated from various sources including RS on a single platform and analyze them efficiently in a spatial-temporal domain.

The suitable areas for agricultural use are determined by an evaluation of the climate, soil, and topographical environmental components and the understanding of local biophysical restraints. In this kind of situation, many variables are involved and each one should be weighed according to their relative importance on the optimal growth conditions for crops through Multi-Criteria Evaluation (MCE) and GIS. One of the most useful features of GIS is
the ability to overlay different layers or maps. However, the overlay procedure does not enable one to take into account that the underlying variables are not equally important (Janssen and Rietveld, 1990). One approach that can help overcome such limitations is MCE (Carver, 1991), which has received renewed attention within the context of GIS-based decision-making (Pereira and Duckstein, 1993).

1.2 HISTORICAL DEVELOPMENT OF LAND USE SURVEY

Land use classification is covering land use studies of United Kingdom, India, United States, Japan and U.S.S.R.

The first Land Utilisation Survey (LUS) was started at Britain during 1930s. The survey was instigated by L. Dudley Stamp, Reader and later Professor of Geography at the London School of Economics. Mapping was carried out by volunteers. The maps were published at one inch to the mile (1:63,360) using the Ordnance Survey. Publication of maps and reports began in 1933 and was completed in 1948. The printing plates of the pre-war maps were destroyed in bombing.

In the 1960s a second survey was carried out by Alice Coleman, a geographer and later professor at Dudley Stamp's alma mater, London, followed the Stamp's approach with the help of volunteers. Coleman acknowledged the 'generous encouragement and financial help of Professor Stamp'. The maps were published by the Isle of Thanet Geographical Association, with specific sheets receiving funding from local authorities such as Essex County Council. Published maps were printed at a scale of 1:25,000 using the Ordnance Survey Provisional and First Series maps as a base. Pairs of 10x10km sheets were combined along the lines of the later Second Series (Pathfinder) maps. Coleman's survey employed a much more detailed classification than Stamp's in both urban and rural areas, giving 64 categories grouped into 13 groupings. Manufacturing was further divided by numbers indicating 14 groupings based on
the Standard Industrial Classification as used in the 1951 Census, for example 3 for glass, ceramics and cement, 6 for engineering and shipbuilding, 7 for vehicle manufacture, etc.

Although around 3,000 volunteers completed much of the field work, coverage of only around 10% of the country was published at 1:25,000 due to printing problems. Nevertheless published sheets included the whole of Greater London and industrial Thames-side, giving a snap-shot of London at its peak as a centre of manufacturing.

All the one inch to one mile maps created by the Survey are available online for study at the Vision of Britain website created by the Great Britain Historical GIS, including the unpublished maps of upland Scotland which Stamp deposited with the Royal Geographical Society, plus the ten mile to one inch summary sheets. These maps are still the copyright of Stamp's estate, for 70 years after his death in 1966.

The land use maps of Italy are being published representing Calabria. It is in tune with the implementation of the decisions taken by the Italian National Research in the early 1950s to participate in the drawing of a world map of land utilization. As a result of recommendations made by the Commission on world Land use Survey of International Geographical Union, the Italian delegation to the 1952 International Geographical Congress presented a map, on the scale of 1:200,000 dealing with land utilization in Tuscany. The task of preparing the series was entrusted to the centre of studies in Economic Geography at the University of Naples and design scale and other details were worked out by a committee comprising of the leading Italian specialists in agricultural economics and economic geography (Kish, 1968).

In Poland, under the direction of Kostrowick (1968), Department of Geography, Polish Academy of Sciences developed a new pattern of land
utilization based on agricultural typology, agricultural regionalisation and planning or programming agricultural development.

In China, data were collected on sampling basis from 22 provinces. Besides farm studies other aspects related to agriculture such as food, standard of living of the people, marketing and price level were also considered. However, in the whole study no attempt was made to record the use of land on maps, which is an important aspect in land use study. The entire study which runs to 470 pages contains 206 tables, 62 photographs and only 21 maps, which are mainly devoted to geographical background and China agriculture.

Land use studies conducted by Indian geographers in various parts of the country received inspiration from L.Dudley Stamp, who had attended the 25th session of the Indian Science Congress at Calcutta in 1938. Such studies range from inventories of land use surveys to isolated topical or regional descriptive accounts of land use variations, both in space and time. Recently the studies are shifting towards the application of quantitative techniques in the analysis of various land use components.

The land survey of 24 Parganas and Howrah District conducted by S.P.Chatterjee and land utilization survey in Eastern Uttar Pradesh conducted by M.Shafi have made a strong plea to carry out the land use survey combined with the survey of land capability. It was in the year 1940 that S.P. Chatterjee tried to organise the land use survey in India. By that time, no systematic land use survey was initiated for entire country. Some geographers were engaged in pilot surveys individually. S.P. Chatterjee surveyed 800 villages of West Bengal and brought out eleven land use sheets on the scale of 4 inches to mile. Under the guidance of P. Dayal and A. Sharan, Department of Geography, Patna University, has surveyed three consecutive community development blocks.

Mishra (1964) has studied land use in Khadar and ravines of the Lower-Middle Gomati Valley. He has attempted land use planning for better adjustment
of agriculture to physical environment for optimum exploitation and conservation of natural resources.

The Agricultural Atlas of India (1958), the National Atlas (1957) and Census Atlases (1961) of different states contain choropleth and dot maps relating to land use and crops. These are useful in the analysis of crop distribution and concentration in general way and have potential for more rigorous analysis.

The ultimate goal of land use study is to suggest the planning for better utilization of available land to the society. Land use planning is not recent in its origin but its practice is truly recent. A land use map gives a clear picture of land to the planner who determines its future use and suggests the maintenance of land potentiality.

1.3 LAND CLASSIFICATION VARIOUS TYPES

1.3.1 Land Capability Classification

Most of the researchers have taken physical elements as main criteria and evaluated qualitative land use classification. The land capability classification has been analyzed based on land units, land forms and their relationship to the other physical elements namely, physiographic, slope, geology, soils, land use, land systems, land irrigability, soil erosion, soil depth, geomorphology, water capacity and so on.

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded.

Land capability classification is an interpretative grouping of soil mapping units mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, or other uses on a sustained basis (IARI, 1971). The soils are grouped
according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. It does not include capability of soils for trees, tree fruits, small fruits, ornamental plants, recreation, or wildlife. The land capability classes are further divided into land capability subclasses based on the predominant limitations for land use namely, erosion (e), drainage (w), soil properties(s), and climate(c).

The extent of the area under each association is given below.

- Class I, (Good Cultivable Land).
- Class II (Moderately Good Cultivable Land)
- Class III (Fairly Good Cultivable Land)
- Class IV (Well Suited For Grazing)
- Class V (Fairly Well suited For Grazing & Forestry)
- Class VI (Lands Well Suited For Grazing & Forestry)
- Class VII (Lands Suited For Wildlife & Recreation)
- Class VIII (Water Bodies).

1.3.2 Land Suitability Classification

Land Suitability refers to the ability of a portion of land to tolerate the production of crops in a sustainable way. Such kind of analysis allows identifying the main limiting factors for the agricultural production and enables decision makers to develop crop managements which help increase the land productivity.

According to the FAO methodology (1976), the land qualities such as erosion resistance, water availability, and flood hazard are not measurable. But, as these qualities derive from the "land characteristics", such as slope angle and length, rainfall and soil texture, which are measurable or estimable, it is advantageous to use these values to study the suitability of the land for the intended use. This project aims to identify the potential Land suitability for agricultural crop production based on the physical properties of the land. It was
done in accordance with the framework for land evaluation developed by Food and Agriculture Organization (FAO, 1976). It used remote sensing and GIS application as decision support system involving the integration of spatially referenced data in a problem solving environment.

According to FAO (1982) certain principles are fundamental to the approach and methods employed in land suitability. These basic principles are

- Land suitability is assessed and classified with respect to specified kinds of use.
- Evaluation requires a comparison of the benefits obtained and the inputs needed on different types of land.
- The multidisciplinary approach is required.
- Evaluation is made in terms relevant to the physical economic and social context of the area concerned.
- Suitability refers to use on a sustained basis.
- Evaluation involves comparison of more than a single kind of use.

The procedure of the formulation of climatic and the soil-site criteria to meet the requirements of crops involves the rating of the soil-site parameters as highly suitable S1 (with slight limitations), moderately suitable S2 (moderate limitations) and marginally suitable S3 (severe limitations) and unsuitable (N) classes. An attempt has been made to develop suitability for major crops based on climate and terrain characteristics.

1.3.3 Land Irrigability Classification

Land irrigability classification is an interpretative grouping of soils based on physical and socio-economic factors in addition to the soil irrigability and is primarily concerned with predicting the behaviour of soils when they are brought under irrigation (IARI, 1971).
Class I  -  Lands that have slight soil limitation
Class II  -  Lands that have moderate limitations of soil and drainage for sustained use under irrigation.
Class III  -  Lands that have severe limitations of soil, drainage and slope for sustained use under irrigation.
Class IV  -  Lands that have very severe limitations of topography and soil for sustained use under irrigation.
Class V  -  Unsuitable for irrigation under prevailing conditions but may be brought under irrigation by reclamation and management at high cost.
Class VI  -  Totally lands not suitable for irrigation due to topographic, soil and rock exposure limitations.

1.3.4 Five Fold land utilization Classification

Till 1949-50, the land area in India was classified into five categories known as the five-fold land utilisation classification. These categories were: (i) forests, (ii) area not available for cultivation, (iii) other uncultivated land, excluding the current fallows, (iv) fallow lands, and (v) the net sown area.

1.3.5 Nine Fold land utilization Classification

The above five-fold classification was, however, a very broad outline of land-use in the country and was not found adequate enough to meet the needs of agricultural planning in the country. The states were also finding it difficult to present comparable data according to this classification owing to the lack of uniformity in the definitions and scope of classification covered by these five broad categories. To remove the non comparability and to break up the broad categories into smaller constituents for better comprehension, the Technical Committee on Co-ordination of Agricultural Statistics, set up in 1948 by the Ministry of Food and Agriculture, recommended a nine-fold land-use
classification replacing the old five-fold classification and also recommended standard concepts and definitions for all the states to follow

(i) **Forests:** This includes all lands classed as forest under any legal enactment dealing with forests or administered as forests, whether state-owned or private, and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing lands or areas open for grazing within the forests should remain included under the forest area.

(ii) **Area under Non-agricultural Uses:** This includes all lands occupied by buildings, roads and railways or under water, e.g. rivers and canals and other lands put to uses other than agriculture.

(iii) **Barren and Un-culturable Land:** includes all barren and unculturable land like mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost, should be classed as unculturable whether such land is in isolated blocks or within cultivated holdings.

(iv) **Permanent Pastures and other Grazing Lands:** includes all grazing lands whether they are permanent pastures and meadows or not. Village common grazing land is included under this head.

(v) **Land under Miscellaneous Tree Crops, etc.:** This includes all cultivable land which is not included in ‘Net area sown’ but is put to some agricultural uses. Lands under Casurina trees, thatching grasses, bamboo bushes and other groves for fuel, etc. which are not included under ‘Orchards’ should be classed under this category.

(vi) **Culturable Waste Land:** This includes lands available for cultivation, whether not taken up for cultivation or taken up for cultivation once but not cultivated during the current year and the last five years or more in
succession for one reason or another. Such lands may be either fallow or covered with shrubs and jungles, which are not put to any use. They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. Land once cultivated but not cultivated for five years in succession should also be included in this category at the end of the fifth years.

(vii) Fallow Lands other than Current Fallows: This includes all lands, which were taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than five years.

(viii) Current Fallows: This represents cropped area, which are kept fallow during the current year. For example, if any seeding area is not cropped against the same year it may be treated as current fallow.

(ix) Net area Sown: This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

1.3.6 Agricultural Classification

In 1935 an attempt was made (Hartshorne and Dicken) to delineate the agricultural regions of North America and Europe on the uniform statistical basis. It was probably the first attempt of a comparative study of agriculture of two continents, based on statistical measurements, referring mainly to the relative importance of different crop and livestock products.

The most important step towards agricultural classification on a world scale was made by Derwent Whittlesey (1936). His classification is based on a broad range of agricultural activities such as "(1) crop and livestock combinations, (2) methods employed to grow crops and husband livestock, (3) the intensity of application to the land of labour, capital and organization,(4) the method of disposal of the farm products, (5) the farm buildings and structures
commonly found necessary to carry on the agricultural activities". Basing on these criteria he distinguished 13 major agricultural regions in the world. He also indicated in a possibly most accurate way how the criteria should be applied to include a given agriculture in one or another region; however, he suggested no quantitative measurement for those criteria, in spite of the fact that some of them were easily quantifiable (Institute of Geography and spatial Organisation Polish Academy of science).

1.4 LANDUSE CLASSIFICATION

There is no one ideal classification of land use and land cover, and it is unlikely that once could ever be developed. There are different perspectives in the classification process, and the process itself to be subjective, even when an objective numerical approach is used. There is, in fact, no logical reason to expect that one detailed inventory should be adequate for more than a short time, since land use and land cover patterns change in keeping with demands for natural resources. Each classification is made to suit the needs of the user.

In order to address the issues associated with classification like class definition, multiple land uses on a single land parcel, minimum represent able area and to standardize the LULC information that could be generated using remote sensing data. Anderson (1971) developed some criteria for classification system.

Classification system attempt to group similar land use/ land cover patterns in a rational linkage or hierarchy based on common attributes. A methodological classification system can be developed only through the establishment of hierarchies of classes, and such classes also permit inductive generalizations.

Many attempts have been made to standardize land classifications, but no one system appears to be acceptable to all users. The hierarchical system devised
by the geological survey (Anderson et al., 1976) represents the closest approach to a national system that has yet been proposed.

Features of the USGS system

This hierarchical system incorporates the features of several existing classification systems that are amenable to data derived from remote sensors, including imagery from satellites and high – altitude aircraft. The system attempts to meet the need for current overviews of land use / land cover on a basis that is uniform in categorization at the generalized first and second levels. It is intentionally left open ended so that independent agencies may have flexibility in developing more detailed land – use classifications at the third and fourth levels.

<table>
<thead>
<tr>
<th>Level I (and map color)</th>
<th>Level II</th>
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| 1. Urban or built-up land (red) | 11. Residential  
12. commercial and services  
13. Industrial  
14. Transportation, communications, and utilities  
15. Industrial and commercial complexes  
16. Mixed urban or built-up land  
17. Other urban or built-up land |
22. Orchards, groves, vineyards, nurseries, and ornamental horticultural areas  
23. Confined feeding operations  
24. Other agricultural land |
| 3. Range land (light orange) | 31. Herbaceous rangeland  
32. Shrub and brush rangeland  
33. Mixed rangeland |
| 4. Forest (green) | 41. Deciduous forest land  
42. Evergreen forest land  
43. Mixed forest land |
| 5. Water (dark blue) | 51. Streams and canals  
| 52. Lakes  
| 53. Reservoirs  
| 54. Bays and estuaries |
| 6. Wetland (light blue) | 61. Forest wetland  
| 62. Non forested wetland |
| 7. Barren land (gray) | 71. Dry salt flats  
| 72. Beaches  
| 73. Sandy area other than beaches  
| 74. Bare, exposed rock  
| 75. Strip mines, quarries, and gravel pits  
| 76. Transitional areas  
| 77. Mixed barren land |
| 8. Tundra (green - gray) | 81. Shrub and brush tundra  
| 82. Herbaceous tundra  
| 83. Bare ground tundra  
| 84. Wet tundra  
| 85. Mixed tundra |
| 9. Perennial snow or ice (white) | 91. Perennial snowfields  
| 92. Glaciers |

*Source: Remote Sensing and Image Interpretation, Thomas M. Lillesand et.al, 2012*

Following Anderson landuse classification, in India NRSC (National Remote Sensing Centre) brought out a landuse classification (1988-89) and National Waste land Development Board (NWDB) set in 1985, for preparing wasteland classification through image interpretation.

### 1.5 LEVELS OF INTENSITY AND APPROACHES

- Three levels of intensity may be distinguished: reconnaissance, semi-detailed and detailed. These are normally reflected in the scales of resulting maps.

- Reconnaissance surveys are concerned with broad inventory of resources and development possibilities at regional and national scales.
Surveys at the semi-detailed, or intermediate, level are concerned with more specific aims such as feasibility studies of development projects. The work may include farm surveys; economic analysis is considerably more important, and land evaluation is usually quantitative. This level provides information for decisions on the selection of projects, or whether a particular development or other change is to go ahead.

The detailed level covers surveys for actual planning and design, or farm planning and advice, often carried out after the decision to implement has been made.

1.6 TWO-STAGE AND PARALLEL APPROACHES TO LAND EVALUATION

A two-stage approach in which the first stage is mainly concerned with qualitative land evaluation, later (although not necessarily) followed by a second stage consisting of economic and social analysis;

A parallel approach in which analysis of the relationships between land and land use proceeds concurrently with economic and social analysis. The two-stage approach is often used in resource inventories for broad planning purposes and in studies for the assessment of biological productive potential.

1.7 LAND CHARACTERISTICS, LAND QUALITIES AND DIAGNOSTIC CRITERIA

The land suitability classifications in the first stage are based on the suitability of the land for kinds of land use which are selected at the beginning of the survey, e.g. arable cropping, dairy farming, maize, tomatoes. The contribution of economic and social analysis to the first stage is limited to a check on the relevance of the kinds of land use. After the first stage has been completed and its results presented in map and report form, these results may
then be subjected to the second stage, that of economic and social analysis, either immediately or after an interval of time.

Figure 1.1. Two-Stage and Parallel Approach to Land Evaluation

A land characteristic is an attribute of land that can be measured or estimated. Slope angle, rainfall, soil texture, available water capacity and biomass of the vegetation are examples of land characteristics. Land mapping units, as determined by resource surveys, are normally described in terms of land characteristics. If land characteristics are employed directly in evaluation,
problems arise from the interaction between characteristics. For example, the hazard of soil erosion is determined not by slope angle alone but by the interaction between slope angle, slope length, permeability, soil structure and rainfall intensity. Because of this problem of interaction, it is recommended that the comparison of land with land use should be carried out in terms of land qualities.

Land quality is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use. Soil qualities may be expressed in a positive or negative way. Examples are moisture availability, erosion resistance, flooding hazard, nutritive value of pastures and accessibility. Land qualities can be estimated or measured directly, but are frequently described by means of land characteristics. Qualities or characteristics employed to determine limits of land suitability classes or subclasses are known as diagnostic criteria.

A diagnostic criterion is a variable, which has an understood influence upon the output from, or the required inputs to, a specified use, and which serves as a basis for assessing the suitability of a given area of land for that use. This variable may be a land quality, a land characteristic, or a function of several land characteristics. For every diagnostic criterion there will be a critical value or set of critical values, which are used to define suitability class limits.

1.8 WATERSHED

A watershed can be defined as the land area that contributes runoff to a particular point along a waterway. A typical watershed can cover tens to hundreds of square miles and several jurisdictions.

Watershed and sub watershed units are most practical for local plans. Each watershed is composed of many individual sub watersheds that can have their own unique water resource objectives. A watershed plan is a
comprehensive framework for applying management tools within each sub watershed in a manner that also achieves the water resources goals for the Watershed as a whole.

The terms “watershed” and “sub watershed” are *not* interchangeable. The term watershed is used when referring to broader management issues across an entire watershed, while the term sub watershed is used to refer assessment level studies and specific projects within the smaller sub watershed units.

### 1.9 RELATED TERMINOLOGIES AND DEFINITIONS

**Land** comprises the physical environment, including climate, relief, soils, hydrology and vegetation, to the extent that these influence potential for land use. It includes the results of past and present human activity, e.g. reclamation from the sea, vegetation clearance, and also adverse results, e.g. soil salinization. Purely economic and social characteristics, however, are not included in the concept of land; these form part of the economic and social context. (FAO,1995).

**Landuse** shows how people use the landscape – whether for development, conservation, or mixed uses.

**Land cover** indicates the physical land type such as forest or open water whereas land use documents how people are using the land.

**Land evaluation** is concerned with the assessment of land performance when used for specified purposes. It involves the execution and interpretation of basic surveys of climate, soils, vegetation and other aspects of land in terms of the requirements of alternative forms of land use. To be of value in planning, the range of land uses considered has to be limited to those which are relevant within the physical, economic and social context of the area considered, and the comparisons must incorporate economic considerations.
**Land mapping unit** is a mapped area of land with specified characteristics. Land mapping units are defined and mapped by natural resource surveys, e.g. soil survey, forest inventory. Their degree of homogeneity or of internal variation varies with the scale and intensity of the study. (FAO, 1983).

**Land characteristic** is an attribute of land that can be measured or estimated. Examples are slope angle, rainfall, soil texture, available water capacity, biomass of the vegetation, etc.

**Land capability classification** is an interpretative grouping of soil mapping units mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, or other uses on a sustained basis. (IARI, 1971)

**Land quality** is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use. Land qualities may be expressed in a positive or negative way. Examples are moisture availability, erosion resistance, flooding hazard, nutritive value of pastures and accessibility.

**Land suitability** is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses.

**Land irrigability classification** is an interpretative grouping of soils based on physical and socio-economic factors in addition to the soil irrigability and is primarily concerned with predicting the behaviour of soils when they are brought under irrigation (IARI, 1971).

**Land suitability units** are subdivisions of a subclass. All the units within a subclass have the same degree of suitability at the class level and similar kinds
of limitations at the subclass level. The units differ from each other in their production characteristics or in minor aspects of their management requirements. Their recognition permits detailed interpretation at the farm planning level. Suitability units are distinguished by Arabic numbers following a hyphen, e.g. S2e-1, S2e-2. There is no limit to the number of units recognized within a subclass.

The designation **Conditionally Suitable** may be added in certain instances to condense and simplify presentation. This is necessary to cater for circumstances where small areas of land, within the survey area, may be unsuitable or poorly suitable for a particular use under the management specified for that use, but suitable given certain conditions are fulfilled.

**Diagnostic criterion** is a variable which has an understood influence upon the output from, or the required inputs to, a specified use, and which serves as a basis for assessing the suitability of a given area of land for that use. This variable may be a land quality, a land characteristic, or a function of several land characteristics. For every diagnostic criterion there will be a critical value or set of critical values which are used to define suitability class limits.

### 1.10 ROLE OF WATERSHED IN LAND SUITABILITY

A watershed is an independent hydrological unit from which runoff resulting from precipitation flows past a single point into a large stream, river, lake, or pond. The integrated watershed management is a multidisciplinary approach for rational utilization of natural resources existing in the watershed for optimum and sustained production with minimum hazard. It involves assessment of various thematic resources for its potentials, problems, and generation of developmental action plans in conjunction with socioeconomic constraints, which could be implemented on the ground without endangering ecosystem. Thus, it essentially relates to management of resources, which means proper land use, protection of land against all forms of degradation, enhancement and
maintenance of soil fertility, conservation of water, flood protection, sediment reduction, and improvement of productivity from all land uses. It is necessary to understand the elements of watershed ecosystem and to translate the watershed ecosystem dynamics into predictive statements for different spatial information for analysis (Rao, 1996, 1999). This dynamic nature of a watershed, therefore, has necessitated working out a comprehensive development plan of the watershed for optimum use of its resources. Appropriate soil and water conservation measures play a key role in maintaining overall productivity in a watershed and maintaining the ecological balance as well. Erosion and water control structures are integral part of soil and water conservation program and are important components of the watershed management. Creation and implementation of a proper water resource development plan could even reduce the severity of drought on permanent basis. Specifically, in rainfed areas small increment in the water availability can substantially increase crop yield and lower the risk of crop failure. Concern about widespread soil degradation and scarce, poorly managed water resources has led to the implementation of watershed management activities throughout Asia, Africa, and Latin America (Kerr and Chung, 2001).

1.11 ROLE OF GIS AND REMOTE SENSING IN LAND SUITABILITY ANALYSIS

In recent years, remote sensing and Geographic Information Systems (GIS) have become an integral component of assessments and analysis of land resources for environmental planning efforts. They represent the technology through which data is efficiently collected, and the software that facilitates the organization, analysis, and visualization of that data. Remote sensing imagery has become a viable source of gathering qualitative data on land cover information at local, regional and global scales. In addition, it also facilitates data collection in multi resolution as well as in multi spectral manner. Remote sensing is a powerful tool for generating large amount of data related to nature
and its resources in a relatively short time, and can be a prominent source of information for a Geographic Information Systems.

The land use/land cover pattern of a region is an outcome of land evaluation assessment process. Land use of an area is a result of human controls over the land resources in relatively systematic manner. Information on land use/land cover and possibilities for their use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. The high rate of population growth, climate change and overconsumption of ecosystem services emerge to be the greatest threat and tend to be the biggest challenge for the society to achieve the equilibrium state. The in-depth knowledge gained through the categorization and case studies of land use change will become handy in developing regional and global Land use and Land cover models. The impact of changing land uses relies on the prevailing surface and subsurface hydrologic conditions.

Within a watershed, the dynamics of hydrologic process governed partially by the spatial and temporal characteristics of inputs and outputs of the land use conditions, often it is the forests, which are at risk in the process of Land use and Land cover change. The synoptic view of the area allows better monitoring capability, especially when the coverage is repetitive, interval is short and resolution of the image is high. The roles of geographers become analysing the relationship between various uses of land and planning. This analysis enables people to use the land resources properly and increases the productivity.

GIS is the tool for input, storage and retrieval, manipulation and analysis, and output of spatial data (Marble et al. 1984). GIS functionality can play a major role in spatial decision making, (Ghafari et al. 2000). GIS have the ability to perform numerous tasks utilizing both spatial and attribute data stored in it. Considerable effort is involved in information collection for the suitability
analysis for crop production. Remote sensing in combination with GIS will be a powerful tool to integrate and interpret real world situation in most realistic and transparent way.

1.12 SIGNIFICANCE OF THE STUDY

The problems that limit the productive capacity of land resources in the study area can be categorized by climate, soil and land forms. In this regard, assessment of the land suitability based on land resources and soil characteristic can be important tools for an assessment of land suitability and potential productivity for crop cultivation. It is helpful for agriculture development and planning. It is applicable in micro or local level planning mainly for rain fed agriculture. It assesses basically the various soil potentialities and other requirements for various crop conditions, evolves future plan of action involving crop diversification and determines suitability of different crops for optimizing land use predictions. In order to achieve sustainable and rapid agricultural development, it is necessary to identify real development opportunities for each land suitability classes so as to be able to fully utilize them. Therefore, the study is deemed necessary to resolve the study area problems mentioned above.

1.13 STUDY AREA- OVERVIEW

The Koraiyar watershed is in the mid-portion of the Coimbatore District. It is located between 10° 36’N and 10° 57’N and 76° 48’E and 77° 09’E with an area of about 660 sq.km. It lies in the south western part of Coimbatore near Cheetipalayam at the elevation of 420 meter above Mean Sea Level. It covers four taluks and five blocks. The climate is hot and humid. It receives rainfall mainly from south west and north east monsoon seasons. The Watershed is surrounded in the north by the Noyyal river basin, south by Palar river basin, west by Valayar reserved forest of the Western Ghats and Parambikulam canal in the east. The minimum width of the watershed is 26 Km, runs along the
eastern margin and maximum of 37 Km along the westerner margin, over the Tamil Nadu-Kerala state boundary.

1.14 JUSTIFICATION OF THE PRESENT STUDY AREA

The Koraiyar watershed lies in the mid western part of Tamil Nadu in the vicinity of Palghat gap. Owing to the influence of Palghat gap, the area receives good amount of rainfall than the neighbouring areas during southwest monsoon season. Further, there is a good spell of rainfall due to cyclonic storms during northeast monsoon. In both of these rainfall characteristics, the study area was practicing good agriculture. However for the past two decades, the people are changing their landuse pattern. For example most of the lands once under variety of crop are now converted into coconut plantations. During the recent past, this scenario is again being changed. Therefore, there is need for a scientific study to assess the lands and their inherent suitability for various crops to have optimum utilization of land.

1.15 AIM AND OBJECTIVES

The study aims that each and every piece of land must be utilized optimally and judicially. Hence proper understanding of land is imperative, for which the lands of watershed must be brought under land suitability classes for various crops. In order to achieve these, the study considered the following objectives:

The main objectives are:

1. To demarcate micro watersheds of Koraiyar watershed and to identify various land units for study

2. To analyze various physical resources of Koraiyar watershed through appropriate assessment methods
3. To illustrate land use and land cover for various periods and to bring out changes over space and time in Koraiyar watershed.

4. To assess the watershed characteristics by analyzing the strengths and weaknesses of physical attributes of land and land use of each land units.

5. To examine each land unit by analyzing, weighing and evaluating the crop requirements that determine the degree of land suitability for various crops and

6. To suggest remedial measures and conservation practices for better management of resources of the watershed.

1.16 RESEARCH METHODOLOGY

The following arrays of method have been employed to fulfil the objectives of the study:

1. The base map of the study area has been prepared by uploading the Survey of India topographic maps of 58B/13 & 14 and 58F/1&2) into ArcGIS environment. All the physical and cultural details have been digitized and edited. This map is the base for the preparation of all thematic maps and overlaying analysis to cull out the inferences.

2. These secondary base line data were processed, compiled, computed and mapped in the form of thematic layers for analysis and to understand the existing condition of Koraiyar watershed. The secondary details relating physical and cultural phenomena like rainfall, temperature, relief, slope, geology, geomorphology, soil, drainage, irrigation, landuse, cropping pattern, administrative aspects, livestock, transport network and so on were collected.
3. The Koraiyar watershed has been identified and demarcated based on the concept of watershed demarcation and terrain details. On the basis of which the whole study area, the Koraiyar watershed, has been divided into 8 micro watersheds as it is the planning unit for all development plans.

4. The drainage patterns are terrain veins which explain morphological characteristics of terrain directly or indirectly. Hence morphometric analyses were carried out for all micro watersheds as well as Koraiyar watershed as a whole.

5. The landuse and land cover have been drawn for various periods based on LANDSAT 8 (2014) and LISS III (1990, 2000). The status of land use during these periods and changes over these periods were brought out by analyzing these thematic layers.

6. The micro-watershed has been broken into pieces called land resource units (land unit or land mapping unit) by overlaying geomorphology, slope, soil and land use with the help of GIS technique. Land evaluation table has been brought out that includes the above said parameters and also variables such as rainfall, land capability, soil erosivity, soil texture and soil drainability to evaluate present strength and weakness of each land resource unit as they are the determinant factors in assessing different crop suitability. Subsequently, by assessing the present performance of the land with land use of each land resource unit, the land suitability classes are arrived to bring current and potential suitability for various crops.

7. After preparation of land evaluation tables through ArcGIS environment, the table details (doubtful areas) were verified in the field. During the
field visits, the economic details such as landuse practices and crops have also been drawn as collateral information. This information were the bases to find out the flaw in current practices and to suggest suitable land use, management and conservation techniques so as to have appropriate land use planning for each micro watershed. The same may lead to overall development of Koraiyar watershed comprehensively.

8. Finally by summing up all merits and demerits, how the present usage could be preserved, changes or improved by suggesting appropriate remedial measures and recommendations without hampering the present context of the environment of Koraiyar watershed. By and large in the present work, the study has used the Geospatial Technology as they effective tools in resource analysis study.

1.17 ORGANISATION OF THE THESIS

The present research work is organised into six chapters. The First chapter is on introduction which deals the importance and the role of landuse planning, land classification and their relevant concepts and definition of related variables /phenomena were carried out to understand the nature of the subject matter. The problem and procedure, database, methodology and relevant techniques used are outlined in keeping with the objectives of the study.

The second chapter is on review of literature narrates the land classification land use planning and their related aspects. The relevant literatures were reviewed to pinpoint the relative position of land classification and landuse planning studies in several countries that have been implemented and also to lessons for Indian context to implement it by taking care of the present environment.
Fig. 1.2. Methodology of the Study Area

Physical Layers
- Geology
- Geomorphology
- Soil
- Relief
- Slope
- Rainfall

Morphometry
- Linear
- Aerial
- Relief

Land Use
- 1990
- 2000
- 2014

Groundwater Quality (Pre/Post)
- pH
- EC
- SAR
- TDS

Land Units

Land Suitability Analysis

Agricultural Crop Suitability for Koraiyar Watershed
The third chapter provides an understanding of resources through land resource inventory studies related to physical, economic and social phenomena as they are the precursor to understand the status of the study area. The necessary thematic layers relief, slope, drainage, geology, geomorphology, soil, vegetation, rainfall, land use, crops, irrigation, population density, literacy and transport have been prepared through ArcGIS environment with greater accuracy.

The fourth chapter illustrates micro-watershed characteristics of Koraiyar watershed by having detailed analysis of terrain and its characteristics. It brings out the overall scenario of each micro watershed in respect of the land mapping units, landuse characteristics, morphological characteristics, and ground water, landuse / land cover changes over the space and time.

The fifth chapter brings out the land suitability classification by analysing, weighting and evaluating the relevant variables which determine suitability of land for various crops. For implementing the development plans the prioritization of micro-watersheds in accordance with conservation and management requirements also suggested.

The sixth chapter summaries the findings and conclusions and outlines the implications of the present study for sustainable agricultural development of Koraiyar watershed.