4. Materials and Methods

4. MATERIALS AND METHODS

The methodology has been channelized into three different paths. They are as follows:

a) Visual interpretation of satellite data imageries

b) Digital analysis of satellite digital data and

c) Geographical Information System (GIS) for the generation of model

4.1 VISUAL INTERPRETATION

The procedure for identification, delineation and monitoring of social forestry plantations has been broadly grouped under three headings (Fig.11).

4.1.a. Data collection
4.1.b Preliminary interpretation and
4.1.c. Final interpretation

4.1.a. Data collection

This includes collection of three different data namely,

i) Remote sensing data

The social forestry plantations were monitored using multitemporal satellite images from 1983 acquired from National Remote Sensing Agency (NRSA), Hyderabad. The higher resolution images were obtained keeping in mind the size and type of mapping units of data required for afforestation under various schemes like social forestry, farm forestry etc. The details of the data used are as follows:

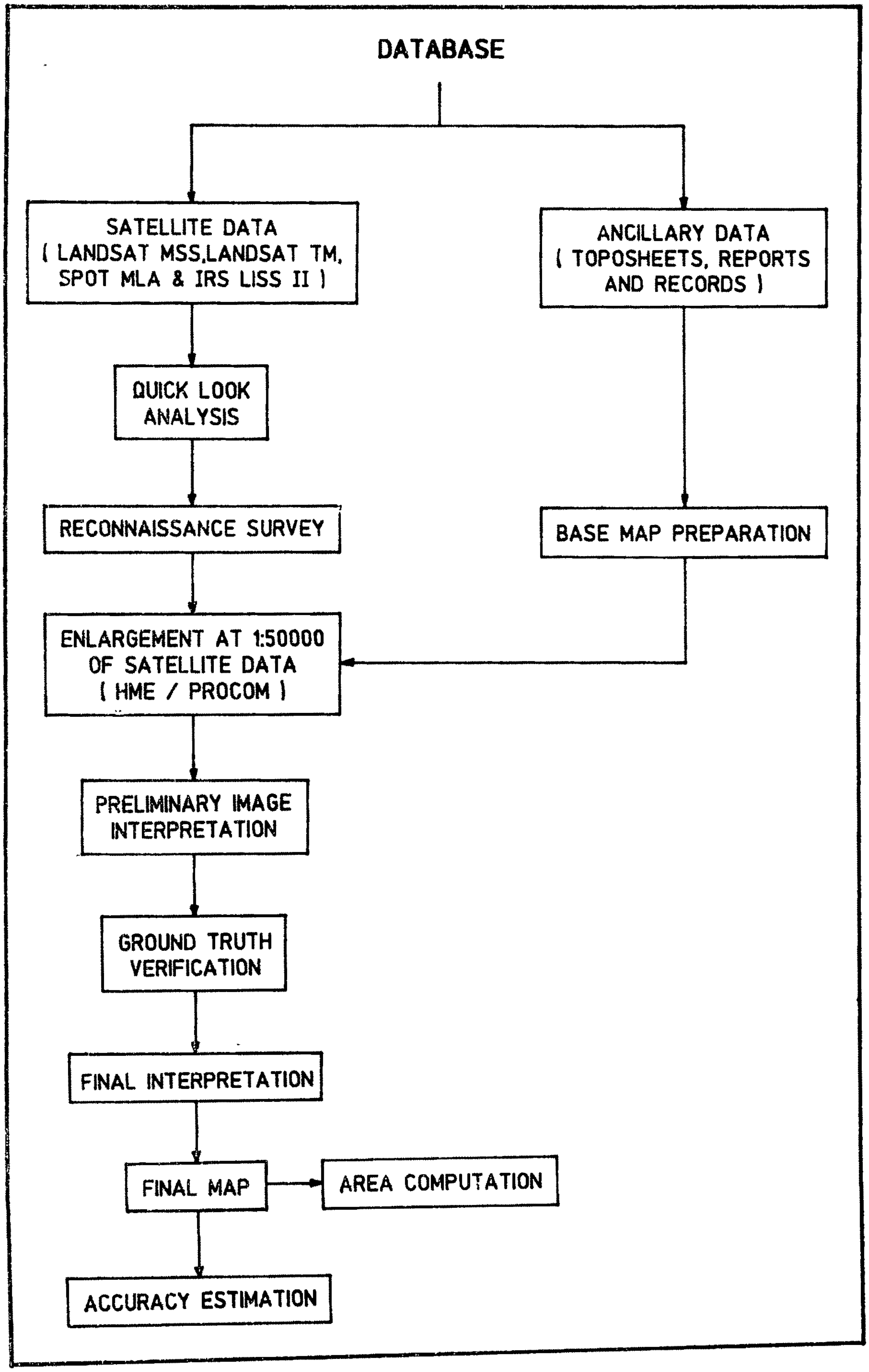

FIG. : 11 FLOW CHART FOR VISUAL INTERPRETATION

Sr. No.	Satellite	Sensor	Bands	Month/Year	Path/Row
1.	Landsat 4	MSS	1 2 4	May,1983	148-044
2.	Landsat 5	TM	2 3 4	Oct.,1986	148-044
3.	SPOT	MLA	1 2 3	Apr.,1989	201-304
4.	IRS	LISS-II	2 3 4	Jan.,1993	032-052

ii) Ancillary data

It consisted of Survey of India (SOI) topographical maps 46 B/9,10,13 and 14 at 1:50,000 scale to prepare a base map. Published reports and records from Forest department and other repositories have also been referred for the preparation of socio-economic information.

iii) Field studies

A reconnaissance field survey of the study area has been carried out to get the overall view of landuse/landcovers. During the survey, different data were collected such as phenology of plants, predominant plant species and its location, soil information and socio-economic information of the local inhabitants.

4.1.b Preliminary interpretation

Multitemporal satellite data viz., Landsat MSS, Landsat TM, SPOT and IRS were enlarged using Large Format Optical Enlarger (LFOE) to get an idea of the different land features of the study area. Using this information alongwith SOI toposheets a preliminary survey was carried out during which related information was obtained for the preliminary interpretation. Multitemporal satellite data were enlarged on High Magnification Enlarger (HME) to 1:50,000 scale by aligning and adjusting it with the 1;50,000 scale base map of that area. The preliminary image interpretation was done based on the tonal variation, specific pattern, shape, size and association alongwith other ground information gathered during the field study.

4.1.c Final interpretation

The preliminary maps were again ground checked by random sampling method, to check the validity and clarify the doubtful areas. Corrections were made on the preliminary maps based on the above information alongwith local information from Forest and Panchayat officials of the same spots.

Finally, accuracy was tested for all the maps at 90% confidence level (Campbell,1987). Areas under different categories were computed using `mm' dotgrid and final drawings were made as per predesigned specifications and cartographic symbols.

4.2 DIGITAL ANALYSIS

The potentials of satellite data can be fully exploited if analysed digitally using a computer. This chapter therefore mainly deals with the methodology used for the analysis of remote sensing data in the form of Computer Compatible Tapes (CCT). The entire methodology has been treated under the following three headings.

(a) Data input

(b) Data processing and

(c) Data output

4.2.a Data Input

It includes data and instrument used for the digital analysis. They are :

(i) Remote sensing data

IRS LISS-II digital data of path 32 and row 52 of March 1991, was acquired from NRSA, Hyderabad.

(ii) Secondary data

It comprised of SOI toposheets 46B/9, 10, 13 & 14, reports and records from panchayat office and other repositories and the ground data collected during the field study.

(iii) Instruments used

To process the above information, software VIPS 32, Hardware VAX 11/780 with work station PERICOLOR 2001 and JOHNSON Digitiser, from Regional Remote Sensing Service Centre (RRSSC), Jodhpur were used.

4.2.b Data processing

A reconnaissance study of the area was made with satellite imagery and SOI maps to get an overall view of landuse and landcover. Information acquired from this study was then used for digital processing of the satellite data. The detailed methodology flow chart for landuse mapping is shown in fig.12.

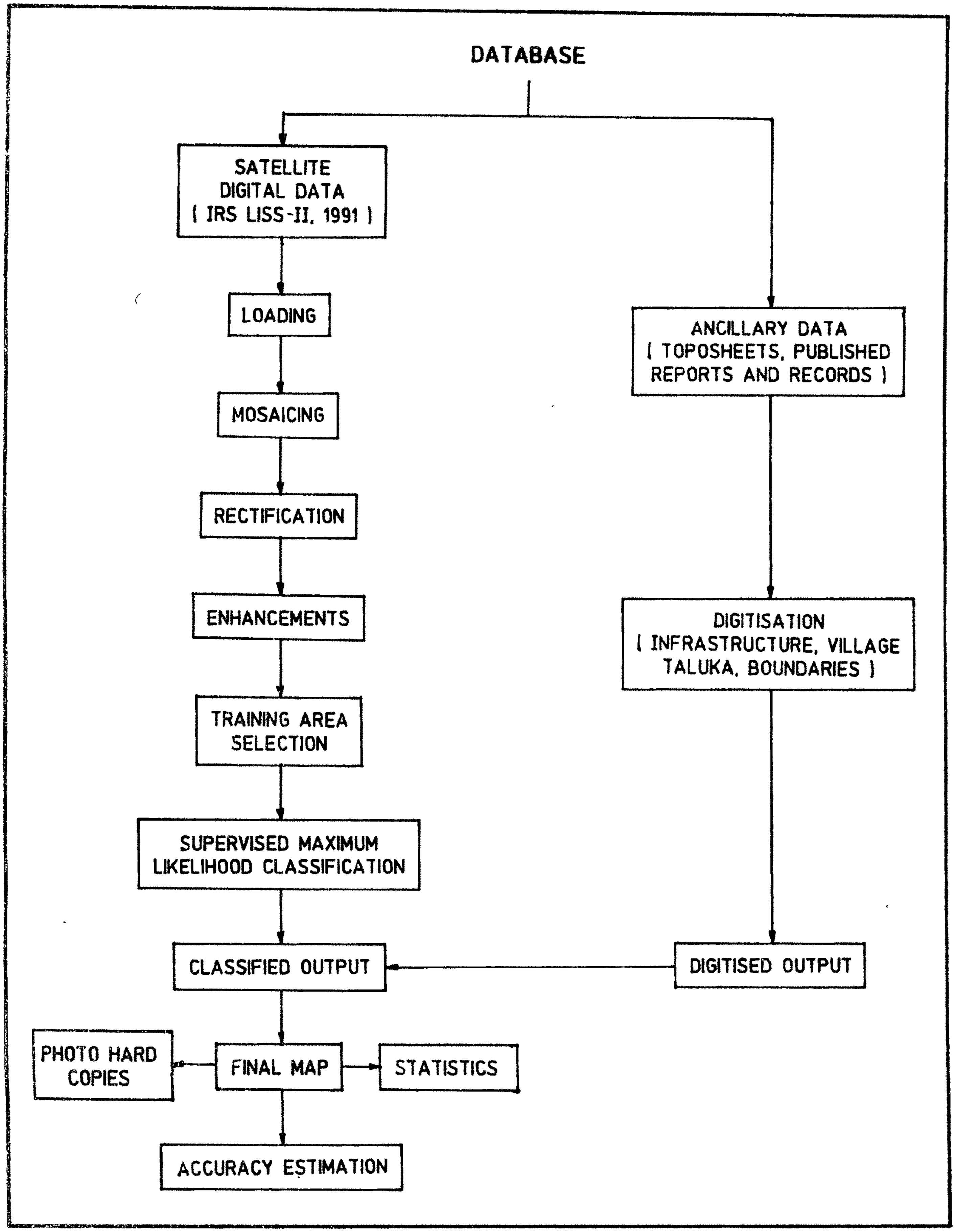

FIG.12 SCHEME REPRESENTING METHODOLOGY ADOPTED FOR DIGITAL ANALYSI

The study area falling under the first and second quadrants of the IRS digital data was loaded and mosaiced. Afterwards, the mosaiced raw data was geometrically rectified by registering it to the SOI topographical maps through identification of Ground Control Points (GCP's) to correct image data distortions. Taluka and village boundaries were also digitised from the records parallely. This information was then overlayed and a mask was generated for the area falling outside the taluka.

Several enhancement techniques like generation of FCC, band combinations such as, Normalised Difference Vegetation Index (NDVI) to study the vegetational strength using the formula

$$NDVI = (Band\ 4 - Band\ 3) / (Band\ 4 + Band\ 3)$$

and Soil Brightness Index (SBI) to study the soil characteristics using the algorithm $SBI = -0.283\ B1 + 0.660\ B2 + 0.577\ B3 + 0.388\ B4$ were attempted.

These were attempted to ensure higher contrast amongst the object for better interpretability on the rectified data. On the enhanced data the training sets in the form of sample areas of known surface features were generated to train the computer to identify similar spots in the entire study area. These training sets were based on tonal variation and ground information. The parameter of multivariate normal distribution comprising mean vector of grey values and covariance matrix of each training sample were computed. Statistics, thus obtained for each training set, representing a particular category of the classification were then utilised to classify the entire scene by adopting supervised maximum likelihood algorithm.

4.2 c Data output

The classified scene was assigned with pseudocolours for the purpose of easy discernibility and was correlated with the ground areas for accuracy estimation

(Campbell, 1987). Finally, village-wise statistics for different landuse were generated from the classified output, taking into consideration the number of pixels for each classes and their percentages. This statistics was then translated in terms of hectares (ha.) or square kilometers (sq.kms.).

4.3.SOIL ANALYSIS

The soil collected from different wastelands was analysed in the laboratory using different techniques. Some selected physical and chemical tests such as texture, type, pH, Electrical conductivity (ECe), soluble and exchangeable ions such Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} Cl^{-}, SO_4^{2-}, CO_3^{2-} were determined.

A saturated extract (1:2) of the soil was made for the determination of pH and ECe (Jackson, 1967). Soluble cations in the soil like Na^{+} and K^{+} were extracted and assayed Flame Photometrically (Richards, 1968). Ca^{2+} and Mg^{2+} were determined on Atomic Absorption Spectrophotometer (AAS) following the methods of Gaines and Mitchell (1979). The determination of Sodium-Absorption Ratio (SAR) and Exchangeable Sodium Percentage (ESP) was done as per the standard methods given by Richards (1968).

$$SAR = Na \ [(Ca+Mg)/2]^{1/2}$$

$$ESP = [100 - (-.0126 + .01475 \ SAR)] / [100 + (-.0126 + .01475 \ SAR)]$$

Anions like CO_3^{2-}, HCO_3^{2-} and Cl^{-} were determined titrimetrically (Richards, 1968) and SO_4^{2-} by calorimetric method (Hunt, 1980).

4.4 GEOGRAPHICAL INFORMATION SYSTEM (GIS)

There is an urgent need for social forestry planning model to put vast tracts of wasteland in the study area under productive use. This model will not only bridge the gap between demand and supply for the minor forest produce but also aid the forest planners and local inhabitants in taking suitable decisions for the development of the area. It is a well known fact that a planning model requires multidisciplinary approach which is up-to-date, reliable as well as economical. In this context the recent RS-GIS technology has been found to have vast potential due to advantages over conventional methods for effective and efficient planning of natural resources

The limitation of traditional system in resource planning lies in the multiplicities of agencies generating similar but incompatible data-sets. In such circumstances the present day RS-GIS technology will help in the storage, updation, analysis, spatial modelling and display in the user friendly environment. Such integration facilitates the work by bringing all the different data on a common database. Keeping the above view in mind in the present study an attempt has been made to integrate RS-GIS technology for generating social forestry planning model. The basic concept involved is the integration of all the physical parameters responsible for plantations on a single map, which will serve as a data base for future planning and development of social forestry plantations in Matar taluka of Gujarat. To achieve the above goal the methodology was categorized into the following three headings :

1) Collection of data
2) Integration of data bank and
3) Composite map generation

4.4.1 Collection of data

This included both spatial and non-spatial data. The spatial data was in the form of maps prepared visually as well as digitally. The soil map was prepared by obtaining the soil physio-chemical properties through laboratory, field study and soil survey department of Gujarat Engineering Research Institute (GERI). The per cent slope map was generated from SOI toposheets by using the following formula

$$\text{Per cent slope} = \frac{\text{Elevation}}{\text{Distance}} \times 100$$

The non-spatial data holds linear features, administrative boundaries, demography, livestock, requirement and availability of fuel wood, fodder and other socio-economic data which were collected from different sources, like Panchayat office, Gujarat wood balance report, local information through questionnaires and other published reports and records.

4.4.2 Integration of data bank

Knowing the limitations of conventional integration like, problems in retracing, difficulty in handling large volumes of data and time consuming, the computerised GeospaceGIS along with VAX 11/780 image processing system were used at RRSSC, Jodhpur. Due to non-availability of plotter, the photographs were taken either by transferring them to VAX system and then taking photographs using DUNN camera or directly from the terminal. The procedure evolved consisted of three components. Firstly, to generate a land capability map, secondly to produce a need versus availability map and finally to develop a site suitability map needed for social forestry programme by combining the above two database. The entire process is represented schematically in fig.13.

GIS DATA BASE

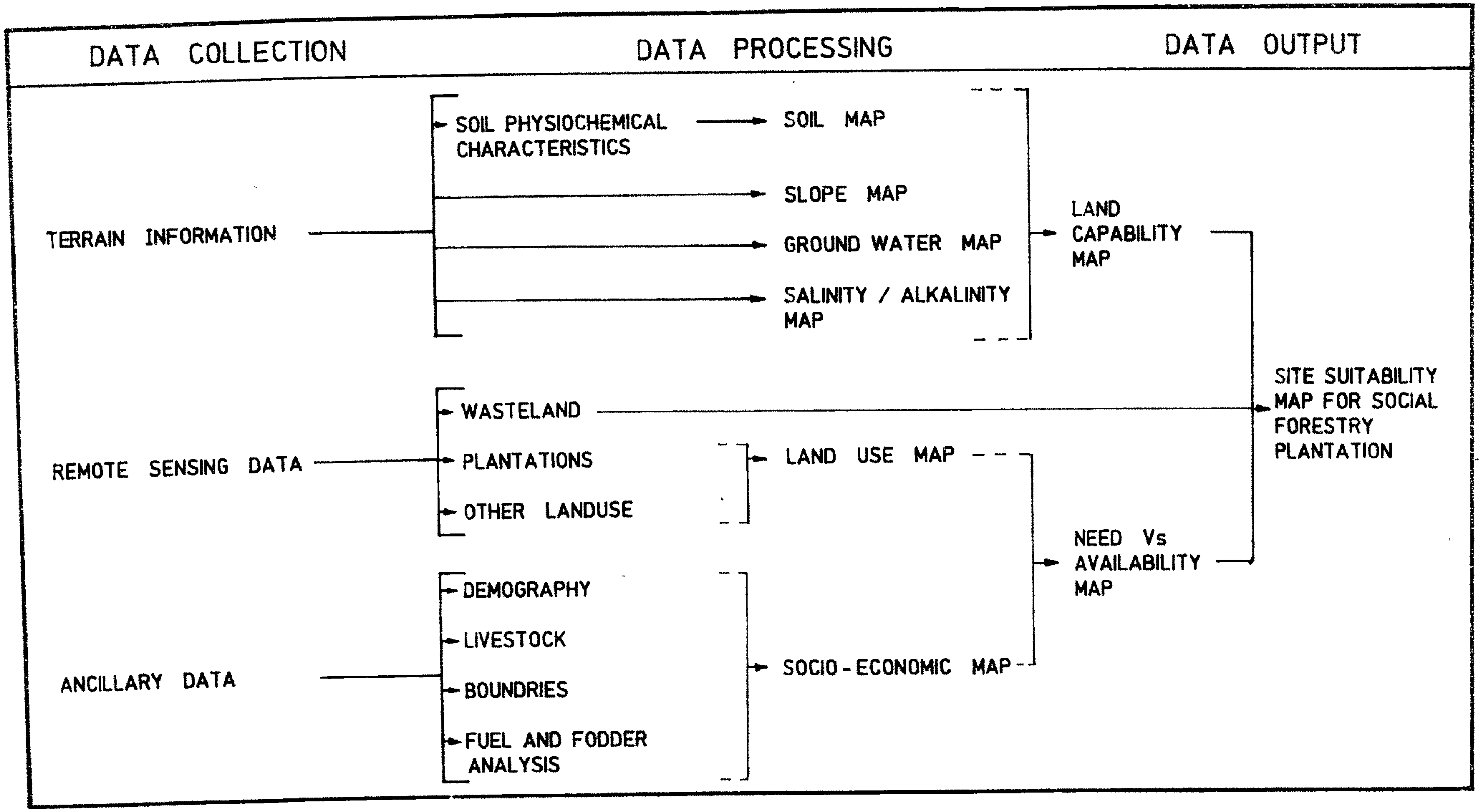

FIG. : 13 A CONCEPTUAL MODEL FOR SOCIAL FORESTRY PLANTATION PLANNING

4.4.3 Land capability map

Land capability indicates the ability of any land to physically sustain or accommodate a certain type of landuse (Whitely *et al.*, 1993). Capability assessment is a standard technique and systematic assessment of different parameters based on the specific requirements. Much work has been done taking into consideration, of different parameters in the field of land capability assessment for various natural resources using GIS. For example, land capability assessment for wasteland (Rao,1993) slope land management (Chang *et al.*, 1992), Agriculture development (Jere and Sridhar, 1993), etc.

In the present study an attempt has been made to generate land capability map for social forestry plantation using GIS. The data base used for the production of land capability are the vital factors that influence the vegetal growth namely soil physio-chemical characteristics like pH, ECe, ESP, soil depth, soil texture, along with the maps of slope, ground water prospectus and salinity/alkalinity.

To derive the land capability each parameter has been selected based on the worst case method i.e., each parameter was rated based on the limitations that it had for an optimum sustenance of plantations according to predefined criteria (Anon *et al.*, 1989; Anon., 1991). In short, it is a measure of what the land can be best used for based on its capability. The criterion adopted for the capability analysis is given in the table 7. The criterion is a matrix, consisting of the different land parameters on one side and classes of capability on the other. Each parameter of the matrix has specific values or range of values for the land parameters with the best value (no limitations) being in the first class and so on. Thus in the matrix the class I showed the best capable land and class IV was the least capable for plantations. Finally the village boundaries were overlayed on the capability map to derive village-wise land capability map.

Table 7. Criteria adopted for the generation of land capability in the study are

Parameters	Land capability classes			
	Good	Moderately Good	Moderately Poor	Poor
Soil Depth	Very deep	Very deep	Very deep	Very deep
Soil Texture	Silty clay loam, clay loam	Silty clay	sandy, sandy clay	Sand
pH	6.0-7.5	7.5-8.4	8.4-9.1	> 9.1
ECe (dSm-1)	0.25	0.25-2.0	2.0-3.0	> 3.0
ESP (%)	15	15-20	20-30	> 30
Slope (%)	0-1	0-1	0-1	0-1
Ground water prospectus	Good	Good	Moderate	Poor
Drainage	Good	Good	Poor	Poor
Salinity/ Alkanity	None	Low	Moderate	Severe

4.4.4 Analysis of Fodder

Using standard values per animal daily need, the yearly requirement of fodder for each village was estimated. For this purpose, the per livestock need was taken as 3650 kg/yr for larger cattle and 750 kg/yr for smaller ones (Anon., 1989).

On the other hand the fodder availability estimation was based on the type of "dry matter" that the land provides - an estimate of the yearly produce from the land. Since no relevant data was available for the study area, different production indices for the different capabilities generated for Palitana taluka of Bhavnagar district were used (Anon., 1989). These indices take into account the totality of "dry matter" produceable by the land that can be used as a fodder. Using this index, a total fodder availability for the village was derived after overlaying the village boundaries on land capability map.

Finally, categorisation was done based on the requirement and availability of fuel and fodder to suggest priority areas for the implementation of afforestation schemes to fulfill the needs of rural population of that area.

4.4.5 Composite map

The first step in this analysis was the merging of land capability map with need vs availability map using Geospace GIS. To achieve this in GIS environment the above two layers were brought to the same scale and the layers were integrated based on Composite Map Unit (CMU'S) with selected parameters (Anon., 1991). A CMU with combination of different selected parameters was done to generate suitability map. To derive the suitability map for wasteland area which is basic input area for social forestry programme, digitally generated wasteland map was overlayed and extracted. The priority was based on the FAO (1976) classification of suitability. The details of the classes are as given below.

(i) Highly suitable

The land having no significant limitations to a sustained application of a given use.

(ii) Moderately suitable

It indicates the land having limitations which in aggregate are moderately severe for sustained application of a given use.

(iii) Less suitable

It denotes the land having limitations which in aggregate are severe for sustained application of a given use and will so reduce the productivity or benefits, or increase the required inputs, thereby the expenditure will be marginally justified.

(iv) Least suitable

The land having limitations which appear so severe as to preclude negligible possibilities of successfully sustained use of the land in the given manner.