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APPLICABILITY OF REMOTE SENSING TECHNIQUE TO MONITOR CHANGES IN LAND USE AND WATER SPREAD AREA

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PREFACE

Land use and land covers are the most important surface characteristics of a region. Various hydrologic processes are influenced by the land use/land cover characteristics of the region. These are the excellent indirect indicators of the hydrologic condition of the region. Remote sensing technique with the GIS based digital interpretation of the satellite data has the immense potential to obtain land use/land cover information with certain degree of reliability.

Drought is a phenomenon, which manifest itself in the ecosystem by depletion of soil moisture, degradation of vegetation and extinction of soil and vegetal cover. The Normalised Difference Vegetative Index parameters analyzed from the multi-spectral and multi-temporal remote sensing satellite data and digital analysis through GIS software could be useful for developing the drought indices. This can be further helpful for the drought analysis and future planning for drought mitigation.

This report entitled "Applicability of Remote Sensing Technique to Monitor Changes in Land Use and Water Spread Area" is a part of the research activities of Hard Rock Regional Centre, National Institute of Hydrology, Belgaum. The study has been carried out Mr. Dilip G. Durbude, Scientist 'B', and Mr. D. S. Rathor, Scientist 'C'.

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ABSTRACT

Information on the rate and kind of changes in land and water resources is essential for planning, management and regularising the use of such resources. Detection of changes in land use/cover over a period of time has become possible in less time, at lower cost and with better accuracy through remote sensing technology. Remote sensing technique is the most advantageous among the new technologies because of its repetitive coverage and the availability of data in different parts of the electromagnetic spectrum. Its application have been operationalised in the natural resources management themes and at present the trend is on integrated surveys to arrive at sustainable development packages. Similarly, the information on estimating hydrological land use/cover types and how they change over time is a prerequisite for sustainable resource development planning. Effective resource management is impossible without a reasonable estimation of the resources in question.

In the present study, land use/land cover and water spread area maps for Yelberga and Kustagi talukas of Koppal district in Karnataka state have been prepared by using the digital interpretation of the IRS satellite data and ILWIS software for the years 1989, 1995 and 1998. Five major land use/land cover categories have been identified as per the spectral, radiometric and spatial variation as well as the tone/colour, shape, size, texture, pattern, location and association of the particular feature. These land use/covers are built-up land, agricultural land, degraded forest, waste land and water bodies. The dominant land use in the study area is agricultural cropland. There is a substantial increase in the water spread area may be due to construction of new water bodies as well as the spectral resolution capacity of IRS LISS III data. This information of the temporal changes in water spread area will be helpful for the surface water potential estimation and its effective utilisation to mitigate the drought problem in the area.

1.0 INTRODUCTION

Land and water are the most important natural resources on which all man's activities are based. The growing pressure of population and human activities are increasing the demand on the limited land and water resources for agriculture, forest, pasture, urban and industrial land uses. Hydrological land use/cover mapping and information on the rate and kind of changes in land uses of a region is an essential part for many planning and management activities concerned with the hydrological aspects of the hemisphere, (Shankarnarayan and Sen, 1977; Christian and Stewart, 1953). Land use are also needed in the analysis of environmental processes and problems that must be understood of it living conditions and standards are to be improved or maintained at current levels, (Anderson et al, 1971).

Various aspects of hydrological studies could be undertaken if information on land use and vegetal cover including their temporal changes are available. The land use and land cover changes have a direct bearing on the hydrologic cycle. The effects of land use and land cover changes on the process of hydrological cycle are realised from the point the precipitation reaches the earth surface. Various hydrological processes such as interception, infiltration, evapo-transpiration, soil moisture, run-off and ground water recharge are influenced by land use/land cover characteristics of the region. Quality of runoff is greatly affected by land use and vegetal cover of the region. Thus, by expressing hydrologic parameters as a function of land use and vegetal cover characteristics of region, it becomes possible to rationally predict the impact, which present and future land use and vegetal cover changes will have on the quality and quantity of runoff. Monitoring of land use and vegetal cover could be helpful in identifying potential areas for soil erosion and assessing soil erosion in quantitative terms. Drought is a phenomenon, which manifests itself in the ecosystem by depletion of soil moisture degradation of vegetation and gradual extinction of soil and vegetal cover. Thus, land use and land cover mapping could be used as a tool for drought monitoring.

In India, like other developing countries efforts are being made for a rational and urban planning. But reliable and integrated information, which is the pre-requisite of land use planning is not available. Such information could only be obtained by employing modern technique and method for research and mapping. Since land use and land covers are dynamic features over space and time, it is difficult to get real time information through conventional means. Also, these methods are time consuming, labourious and with high cost often when the study has time limitation. Spatial variations of land use and land cover generate uncertainties about the point data collected by conventional methods. In recent years, satellite remote sensing techniques have been developed, which are of immense value for preparing on accurate land use map and monitoring changes at regular periodic intervals of time. As such, spatial repetitive and synoptic data from satellites collected over a wide range of electromagnetic spectrum admirably suit the requirements of land use and land cover monitoring. These spatial data indicate the distribution of various land uses and land covers categories in an area. Due to the availability of repetitive data, it is possible to update existing database and base maps for use in various hydrologic purposes. Monitoring of changes in land use/land cover, surface water storage through changes in water spread area and similar dynamic features are possible by this repetitive data. Synoptic coverage of the data helps in studying the integrated effects of various aspects of ecosystems and it is often possible to correlate the cause and effect of changes, which are being monitored. The data collected by various sensors over various regions of electromagnetic spectrum help in differentiating one feature from the other and identify the features, which could not otherwise be deciphered from a single band image. The planners and specialist in various disciplines are forced to use existing date on the land use which is usually outdated because of the pattern of available resources and demand for resources are constantly changing. For economical development of a region, planners need update information, which can be obtained quickly, economically and accurately through remote sensing technique. So, with the advantages of remote sensing data, it is evident that these could effectively be used to prepare land use and land cover mapping and to monitor the temporal changes with time and cost effectively.

Remote sensing data are available in the form of Panchromatic data, Multispectral data, Colour Infrared Photographs and Standard FCC's (False Colour Composites) as well as SLAR Imagery. For processing and mapping the data both digital and visual interpretation technique are available. Visual interpretation technique relies on human interpreter solely. Human eye has limitations in discriminating the objects/tone/colour as compared to a digital computer. While, digital processing of CCT data has the added capability of examining a large quantity of data and objectively classifying it quickly according to the guidelines established by pattern recognition algorithms and by analyst. This processing of spectral data based on pattern recognition technique either utilizes unsupervised classification or supervised classification. It has been observed that computer aided classification gives fairly accurate results where ground features are spectrally separable. When there is a mixing of spectral responses the accuracy detoriates.

In the present study, land use/land cover maps have been prepared for the year 1988,1995 and 1998 and are compared for the changes using IRS LISS II and LISS III data through digital interpretation technique with the help of GIS (Geological Information System) software namely, ILWIS (Integrated Land and Water Information System). These information may be used for agricultural drought assessment and further land use planning.

2.0 REVIEW

Remote sensing programme in India in its present context started with the pioneering experiment in 1970 on the use of colour infrared aerial photographs for the detection of root wilt disease in coconut trees. Since then, there has been tremendous progress and today India ranks among one of the first few countries in the field of remote sensing technology and applications. Wide spread popular interest in the utilization of satellite data for natural resource assessment and monitoring in Indian condition was aroused after the IRS Satellites data were made available in 1991 (Navalgund, 1995).

Land use/cover surveys using remote sensing techniques have been primarily conducted in the country by National Remote Sensing Agency, Hyderabad; Indian Institute of Remote Sensing, Deharadun; Space Application centre, Ahmedabad; Centre of Studies in Resources engineering, IIT, Bombay etc. NRSA (National Remote Sensing Agency) has contributed significantly to the land use/cover mapping using remote sensing techniques. Land use map in the scale of 1:250,000 using Landsat Imagery have been prepared for various regions of Andhra Pradesh, West Coast, Nagaland, Mizoram, Orisa, Uttar Pradesh, Tripura and Arunachal Pradesh.

As such, land use refers to man's activities on land, which are directly related to land (Clawson and Stewart, 1965). Land cover denotes the vegetational and artificial constructions covering the land surface (Burley, 1961). The term land use and land cover is closely related and interchangeable. The purpose for which land is being used, commonly are associated with different types of cover such as forest, agriculture, wasteland or water bodies. The remotely sensed data record information essentially on land cover, from which the information on land use has to be deduced and inferred. Land use/cover classification is nothing but to put similar things together and non-similar things together. In other words "classification is the grouping of subjects into classes on the basis of properties and relationship they have in common". Thus each land use category should be homogeneous in nature. It depends upon the region, which is being studied and numbers of land use classes of units that are being analysed.

Singh and Ghosh (1969) in their detailed reconnaissance geomorphological survey of Sumerpur (Pali) block have found the maps prepared with the aid of aerial interpretation to be 80 per cent correct than those prepared purely based on ground survey data. The type and distribution of land uses within a watershed are important determinants of hydrologic response of a watershed. Remotely sensed data have been used successfully to measure land use distribution within a watershed as well as the land use changes with time (Stafford et.al., 1973).

The application of satellite remote sensing for land use surveys and mapping for a large area is gaining feasibility. Attempts to prepare a land use map of western Rajasthan based on visual interpretation of satellite imagery have been made by Sen and Gupta (1982). Rakshit (1983), in a comparative study of conventional and remote sensing techniques observed that geomorphic mapping on synoptic data base is easier and better than that done by piecemeal information collected during conventional ground survey.

Baldev Sahai (1983) reviewed the state of art in India and suggested a three ties approach; i.e. satellite, aerial, ground, which provide the complete or optimum information. This classification scheme is quite incompatible with remotely sensed data. It gives the land utilisation classes as follows:

(i) Forests

(ii) Area under non agricultural uses

(iii) Barren and uncultivable land

(iv) Permanent pastures and other grazing lands

(v) Miscellaneous trees crops and groves not included in the net area sown

(vi) Culturable waste

(vii) Fallow land other than current fallow

(viii) Current fallow

(ix) Net area sown

Gautam N. C. and Narayan, E. R. A. (1983) have carried out study for land use and land cover inventory and mapping for Andhra Pradesh. The study evaluates how well data from the Landsat MSS could be used to detect, identify and delineate land use features within the Andhra Pradesh state. Chinnamani et al. (1983) investigated land use changes in relation to Hydrology of Bhiwani basin using remote sensing techniques. They have used LANDSAT MSS data in conjunction with historic data acquires from the SOI topographical maps and field data. They used visual interpreration technique for land use changes detection.

Sharma et al. (1984) prepared a land use and land cover map for Deharadun-Roorkee region using visual interpretation technique. Area of each land use/land cover category was determined for the year 1972 (December) and 1977 (April). Singh and Shankaranarayan (1985) have used three ties system viz., air, space and ground for delineating and mapping various natural resources of Indian desert with greater accuracy.

Singh (1986) has stated that side by side comparison of two photographic images or overlaid images of two different periods can be carried out for the land use/cover changes. The fundamental assumption is that any change in the land use will result in change in the reflectance value, which is sufficiently large to register and despite other variables.

Bhar and Bhatia (1987) prepared a land use map of upper Yamuna catchment using remotely sensed data. Six land use categories of hydrologic importance deciphered from the imagery. Similarly, Porwal and Pant (1988) prepared a forest composition cover type map using LANDSAT TM FCC on 1:250,000 scale. LANDSAT TM FCC have been visually interpreted for delineation of forest cover type identified on the basis of tone/colour, texture, pattern and corrected with geographical location.

Singh et al (1988) carried out visual as well as digital analysis for a Paonta Sahib area, a part of Doon valley, representing different part of LANDSAT scene (Path and Row 157/039). The study covered 344.89 Sq. km. Of Paonta Sahib area, a part of the Doon Valley, representing different types of physiography, soils, land use and varied crops as well as natural vegetation. On the basis of this study it was concluded that maximum likelihood classification was more accurate for mapping of various land use/ land cover classes as compared to minimum distance and parallel piped classifier programmes. Similar effort made by Pathan et al in 1991 to study the urban land use mapping of forest cover and land use classes of Ahmedabad city and its environments.

Choubey and Jain (1989) carried out study on land use of Sabarmati basin using multi band Landsat imagery. Seven land use categories were identified from the imagery. Pathan et al. (1989) carried out study on forest cover type and land use classes in Ranikhet Tehsil of U.P. This study highlights the potential of remote sensing technique for monitoring the changes in forest cover and land use classes.

Nguen et al. (1990) has carried out study on analysis of LANDSAT TM and IRS LISS-II data for land use/cover mapping and change detection and concluded that the above sensors images are most useful in land use/cover mapping and change detection, if same sensors data are not available. Choubey (1990) has carried out hydrological land use mapping of Malaprabha and Ghatprabha catchments of Krishna basin. Based on the study, he recommended land use for both catchments taken into account the suitability of soils, its erosion status, the availability of ground water potential and the existing land use practices in the area.

Chandra (1992) has been used IRS 1A LISS II images to classify land use pattern. Choubey et al. (1992) have prepared a land use, surface water bodies agricultural and soil maps from IRS-1A LISS-II imageries. They also suggested for the optimal use of land and water resources from the analysis of maps prepared. Narasimham et al. (1992) has prepared land use/land cover map by using remote sensing data for Tandava reservoir catchment in Visakhapatnam district. The land use/cover derived from LANDSAT TM imagery of 1:250,000 scale has been used for the evaluation of parameters, which are involved in the empirical formulae of runoff estimations. Rathore (1992) has delineated forest cover in the south Aravali mountain region of Rajasthan and Gujrat with the application of remote sensing. The remotely sensed data gives actual vegetation coverage. Using FCC of transparency and satellite imagery paper points, it has been possible to get correct information regarding forest mapping.

Singh et al. (1993) analysed satellite remote sensing data using IRS-IA (LISS-I) FCCs in conjunction with ground truth enabled to identify and to map different land use / land cover categories in Jodhpur district. The extent of different land use / land cover categories from IRS FCC products and revenue record has been computed and tabulated.

Chaurasia et. al. (1996) analysed the multidate remote sensing data of the Tehsil Talwandi Sabo in district Bathinda to map existing land use and temporal changes. It is revealed from the study that land use pattern in the tehsil is not similar to that of general land use pattern prevailing in the State. The area under settlements shows many fold increase while there is no increase in forestland. Sandy areas comprising sand dunes (levelled and unlevelled) require suitable management for proper ecosystem balance.

In 1996, Ghose et al. studied the land use and land cover changes in a Mountainous terrain with the integrated approach of visual interpretation of IRS IB satellite data and ARC/INFO as GIS software for analysis of some other spatial/non-spatial data. Suitability assessment of land where agricultural extension occurred between 1963 and 1993 was made using GIS software package. Land deterioration over the two mapping periods was identified.

Murthy and Venkateswara Rao (1997) studied the temporal variation in land use/land cover of Varaha river basin, Andhra Pradesh by using the visual interpretation technique of the Landsat TM satellite data of the year 1986 and IRS 1A (LISS II) satellite data of the year 1982. The result revealed that the land use/land cover pattern of the area is controlled by local topography, climate and resource and also found the significant changes in the area of built-up land, irrigated land, plantation, degraded forest and upland over a period of six years.

Likewise, Palaniyandi and Nagarathinam analysed the space borne data of the Thiruvallur area of Chengai -MGR district in Tamil Nadu of the years 1986 and 1990 obtained through Landsat TM and IRS 1A, LISS II respactively, for the temporal variation in land use/land cover. It was observed that the built-up area and agricultural land use extensions are on the upward trend, whereas the area under the forest and wasteland has shown a decline trend, cause by both increasing population and related trends in other parameters.

Recently, Rajeev Kumar et al. analysed the land use and land cover changes in the mid-western part of Gohparu Block, Shahdol district, Madhya Pradesh over a period of 30 years from 1967 to 1996. The loss of vegetation cover was estimated to be 22 per cent and 14 per cent of the land was found to have been transformed into wasteland between 1967 and 1996.

The land use/cover classification is shown in table no. 1, which was prepared by NRSA, Hyderabad. The same classification adopted for nationwide land use/cover mapping at 1:250000 scale. In the present study nine hydrologically land use/land cover categories are selected for mapping and change detection.

Table 1. Land Use/Cover Cassification System

Level I	Level II
1. Built-up land	1.1 Built-up land
2. Agricultural land	2.1 Crop land (i) Kharif (ii) Rabi (iii) Double cropped 2.2 Fallow 2.3 Plantation
3. Forest	3.1 Evergreen/Semievergreen 3.2 Deciduous 3.3 Degraded scrub land 3.4 Forest blank 3.5 Forest plantation 3.6 Mangrove
4. Waste land	4.1 Salt affected land 4.2 Water logged land 4.3 Marshy/Swampy land 4.4 Gullied/Ravineous land 4.5 Land with or with out scrub

	4.6 Sandy area (Coastal and Desertic) 4.7 Barren Rocky/Stony areas
5. Water bodies	5.1 River/Stream 5.2 Lake/Reservoir/Tank/Canal
6. Others	6.1 Shifting cultivation 6.2 Grass land/ grazing land 6.3 Snow covered/glacial area 6.4 Mining area

3.0 STATEMENT OF THE PROBLEM

Land use and land covers are the most important surface characteristics which influences the various hydrologic processes such as infiltration, evapotranspiration, soil moisture status etc. Remote sensing can help in identifying surface cover and other land surface features and these information can be used to infer the hydrological features. A land use/ land cover and normalised difference vegetation index could be helpful to identify the drought like agricultural drought studies.

Drought is a phenomena, which manifest itself in the ecosystem by depletion of soil moisture, degradation of vegetation and extinction of soil and vegetal cover. Kustagi, Yelberga and Koppal talukas of the Koppal District i.e. undivided Raichur district are declared as a drought region. Kustagi taluka of the Koppal district is recorded severe rainfall deficiency (46%) during the year 1998. Therefore, in the present study, Yelberga and Kustagi talukas are chosen for monitoring the temporal changes in hydrological parameters like land use and land cover and surface storage potential (changes in water spread area) using digital interpretation of LISS II and LISS III IRS satellite data for the year 1989,1995 and 1998. This study will helpful for the surface water potential estimation and monitoring of agricultural drought in future to mitigate the drought problems in the area.

4.0 STUDY AREA AND DATA AVILABILITY

4.1 Study Area

The present study was conducted for Yelberga and Kustagi talukas of Koppal district (i.e. undivided Raichur district) of Karnataka state. These talukas are declared as drought prone area. This study area lies between Longitude 75^{0}46'18" E to 76^{0}29'27" E and Latitude 15^{0}17'57"N to 16^{0}N. The geographical area of Yelberga and Kustagi talukas are 147830 ha and 135779 ha respectively. These two talukas are bordered to Dharwar and Bagalkot district (figure 1). Physiographically the area could be divided into hills, pediments and plains, which have different physiographic characteristics. On an average the area is surrounded by basaltic terrain. The most of drains are west to east direction from higher elevation of 700m to the lower elevation of 500m from m.s.l. (Mean Sea Level). One of the major river in the area is Hire or Maski Nadi. Climatologically, the study area is coming under arid to sub-arid region. The average annual rainfall is very low, i.e. 592.88 mm. Mainly two types of soils are dominated in this region i.e. Black soil and Red laterite soil. In some patches of the area especially, in Kustagi taluka the soil is toward the infertility due to the increase salinity.

4.2 data Availability

The present study is carried out by preparing or using combinely the land use/ land cover map of the year 1988, 1995,1999 and its changes through GIS (Geological Information System) software namely, Integrated Land and Water Information System (ILWIS). For this purpose the IRS LISS satellite row data was procured from NRSA, Hyderabad. The conventional data such as Survey of India toposheets at 1:250000 scale and other reference material on the subject like Land use/ land cover map of Raichur district of Karnataka of the year 1989 prepared by Karnataka State Remote Sensing Technology Utilisation Centre, Department of Science and Technology, Banglore have been referred in this study. The monthly rainfall data for 20 years (1980-1999) have been collected from the statistical department.

The study area is covered in two LISS II scenes of IRS LISS II data for the year 1988 and 1995, while one LISS III scene of IRS LISS III data product for the year 1998. The specification about the data used is given in the table 2 and image index in figure 2.

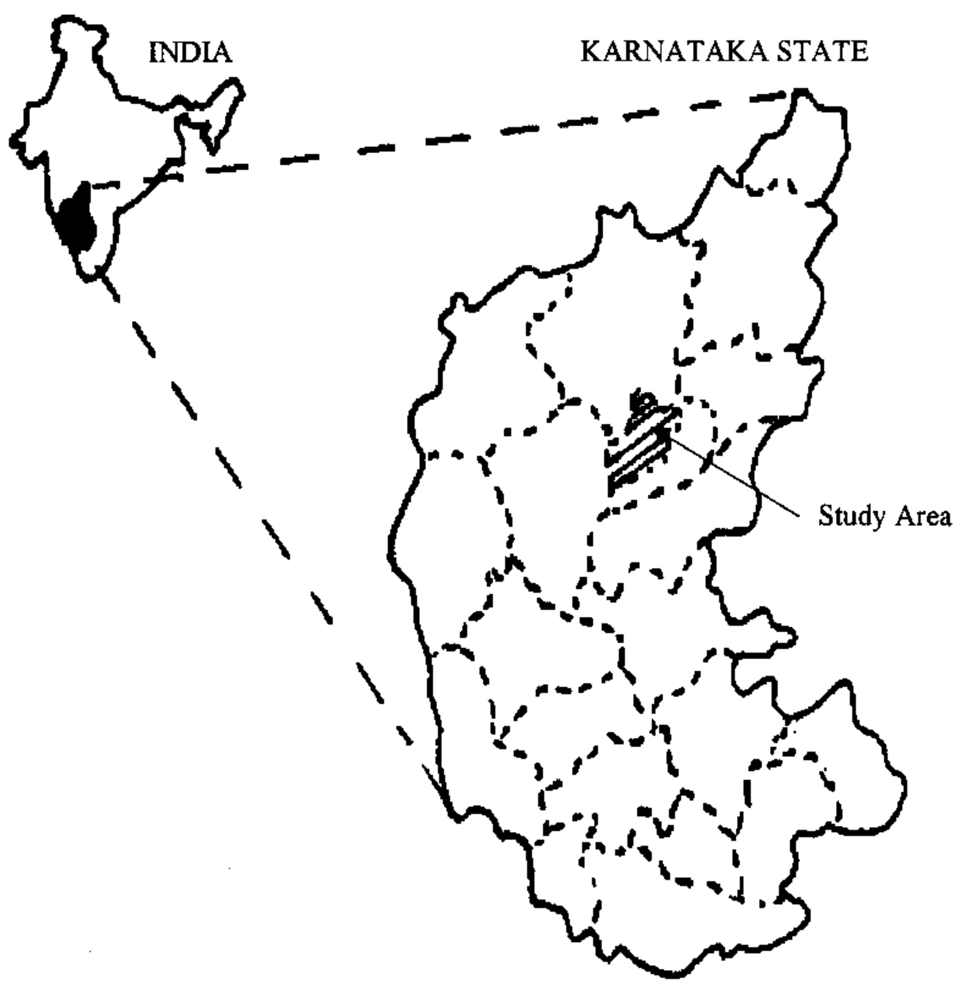


Figure1. Location Map of Study Area

The study area is covered in two survey of India toposheets namely, 57A and 48M at 1:250,000 scale. The base maps of the talukas have been prepared from Topo sheets. The area covered in 48M and 57A Topo sheets are shown in the Topo map index figure 3.

Table 2. Specification details of the IRS Satellite Data

Sr. N.	Month/Year	Path/Row	Satellite / Sensor	Bands	Product
1.	Mar./1989	27/57	IRS 1B/ LISS II A2,B2	2,3,4	FCC
2.	Oct./1989	27/57	IRS 1B/ LISS II A2,B2	2,3,4	FCC
3.	Apr./1995	27/57	IRS 1B/ LISS II A2,B2	1,2,3,4	STPC0026J*
4.	Nov./1995	27/57	IRS 1B/ LISS II A2,B2	1,2,3,4	STPC0026J*
5.	Nov./1998	98/62	IRS 1D/ LISS III	2,3,4,5	STPC0026J*
6.	Apr./1999	98/62	IRS 1C /LISS III	2,3,4,5	STPC0026J*

*STPC0026J - Digital multiband standard raw data (without geo-reference) product on LOGSOWG format stored in 560 MB CD-ROM.

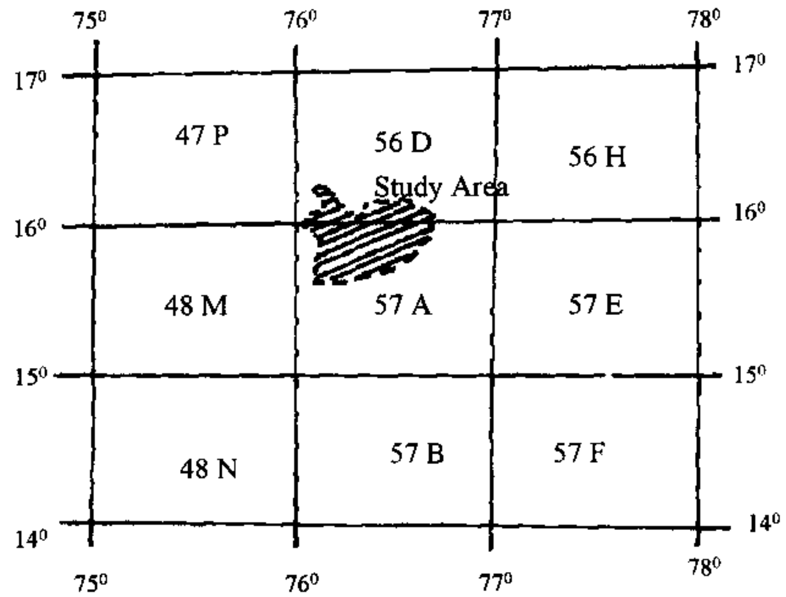


Figure2.Topo Index Map of Study Area

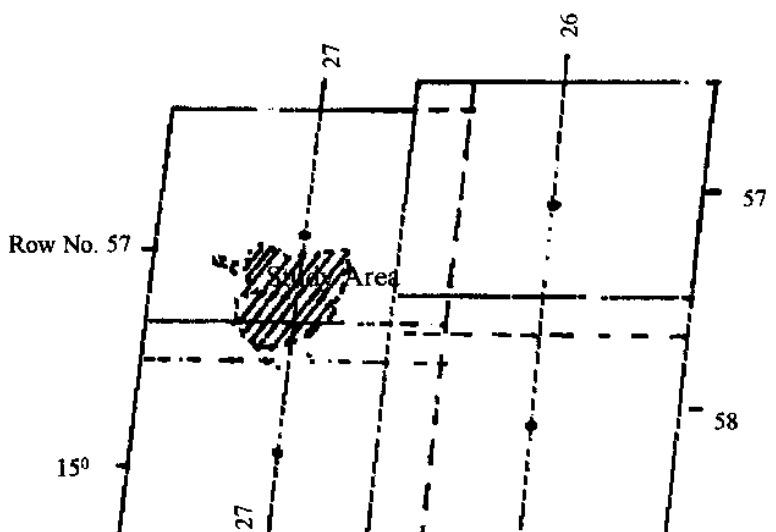


Figure3. Image Index Map of Study Area

5.0 METHODOLOGY

Remote sensing and GIS applications have been operationalised in most of the natural resources management themes and at present the trend is on integrated surveys to arrive at sustainable developmental packages. A Geographic information system (GIS) is a computer-based system for capturing and processing spatial data of geographic nature. GIS is used for the input storage and retrieval functions provide the storage and maintenance of both spatial and related nonspatial data files. Data manipulation functions perform analytical functions such as reclassifications, overlay and neighborhood analysis task etc. A tabular and graphic output subsystem is used for display of spatial and tabular data. ILWIS is an acronym for the Integrated Land and Water Information System. It is a Geographic Information System (GIS) with image processing capabilities. As a GIS package, it allows to input, manage, analyze and present geographical data. It is a PC based image processing and data base GIS. ILWIS version 2.2 operates on Microsoft windows systems.

In the present study digital interpretation was carried out by using Integrated land and water Information system, to identify the hydrologically important land use/ land cover features for the number of IRS LISS scenes for the years 1998, 1995 and 1998. The IRS LISS II and LISS III data scenes for the various years were imported in the ILWIS format and Geometrically corrected. Well-defined objects, both on the images and the base map, are used as a ground control points (GCPs). There are four basic steps involved in the geometric correction

1. GCPs are selected. GCPs are objects, e.g., centre of water bodies, road intersections, etc.
2. A geometrically corrected grid in latitude and longitudes is prepared.
3. Latitudes and longitudes in the geometrically corrected grid are transformed to image x and y coordinates. These points become new locations in the image.
4. At locations, as computed above, DN is resampled. Nearest neighbour resampling technique is used. In this technique, DN remains unchanged.

The base map of the Talukas namely, Yelberga and Kustagi has been prepared from the toposheets at 1:250,000 scale. For this purpose, the toposheets first scans and imported in ILWIS software for the georeferencing with the local coordinate system. Coordinate system with coordinates expressed in meters is selected for base map. It is an arbitrary system. The permanent features like Roads, Railway line, main streams are digitized. This map is used to register the satellite images.

Data are geocorrected applying affine transformation and nearest neighnour resampling. Resampling is corrected at square pixel size of 36 meters. Since, these talukas comes in two sub-scenes of LISS II images, two sub-images are taken and are separately rectified and glued subsequently as shown in figure no. 4. Six rectified satellite images (with four bands 1,2,3, 4) for each taluka are classified. Supervised classification with box classifier and maximum likelihood decision rules classification algorithm is used.

The following are the important steps for conducting a rigorous and hopefully useful supervised classification:

1. An appropriate classification scheme must be adopted.

2. Select representative training sites, including an appreciation for signature extension factors, if possible, for each theme (class).

3. Extract statistics from the training site spectral data. e. g. Mean, Standard Deviation, Co-variance matrix for each class in each spectral band.

4. The training sites are analysed to select the appropriate features (bands) to be used in the classification process; this may involve both computer graphics and/ or statistical methods of evaluating the degree ofpurity and separability between classes.

5. Select the appropriate classification algorithm.

6. Classify the imagery into m classes.

7. Statistically evaluate the classification accuracy with post-field visit of the classified area.

Analyst has to select sites within the image that are representative of the land cover classes of interest. These sites should not be a typical, but the one that represents the norm for each class. The image co-ordinates of these sites are identified and used to extract statistics from the spectral data of these areas. The general rule is that if the training data are extracted from N bands, the minimum number of pixels in a class should be N+1. Ideally, greater than 10N pixels of training data are collected for each class. Once the training statistics have been systematically collected from each band for each class of interest; judgement must be made to determine those, bands that are most effective in discriminating each class from all others. This procedure is commonly called feature selection. Feature selection may involve both statistical (such as divergence) and graphical (ellipse of bispectral plots) analysis to determine the degree of class separability in the training data set in the image.

Various classification methods may be used to assign an unknown pixel to one of the class. The choice of the particular classifier or decision rule depends on the nature of the input data and desired output.

6.0 RESULTS AND DISCUSSION

Various land use/cover features in the Yelberga and Kustagi talukas of Koppal district of Karnataka State were delineated by digital interpretation through ILWIS. The geometrically corrected rectified images were classified by using box classification and maximum likelihood decision rules as classification algorithm. The Level II classification was adopted to prepare land use/cover map in this study.

The Yelberga and Kustagi talukas have been divided into five major land use/land cover categories. These include built-up-land, agriculture land, forest, waste land and water bodies. In this connection, in an average 20-30 training sites for each class and each rectified image have been selected. For each class, extracted the statistics of the training sites spectral data i.e. mean, standard deviation and co-variance matrix. The training sites are analysed to select the appropriate features to be used in the classification process. Thus the land use/land cover maps for the year 1995 and 1998 of the Yelberga and Kustagi talukas are prepared as shown in figure 5, figure 6 and figure 7. For the year 1989, the result obtained through the scanned FCC of the IRS LISS II data was not appropriate due to the spectral variance and some error in scanning itself. Therefore, the analysed data by Karnataka State Remote Sensing Technology Utilisation Centre, department of Science and Technology, Bangalore has been used as shown in figure 8 and figure 9. The yearwise coverage of the major land use and land cover identified in both talukas and percentile coverage of each category have been computed and tabulated as shown in table 3 and table 4 and is graphically represented as shown in figure 10.

The salient features and the temporal changes of the land use/cover identified in the study area are described below.

1. Agriculture land

In general agricultural land can be defined as land used primarily for production of food and fiber. The category includes the Kharif cropland, Rabi cropland, Double cropland and agricultural fallow land. This category of land use due to its medium to smooth texture, bright red to red tone and high DN (digital number) value in infra red band and low DN value in visible red band could be easily identified and mapped. From the multidate IRS LISS images, it is possible to delineate the cropland in different seasons. In the study area, generally the Monsoon started in first week of June and Rabi season started in the last week of October. The spectral and temporal resolution of the IRS

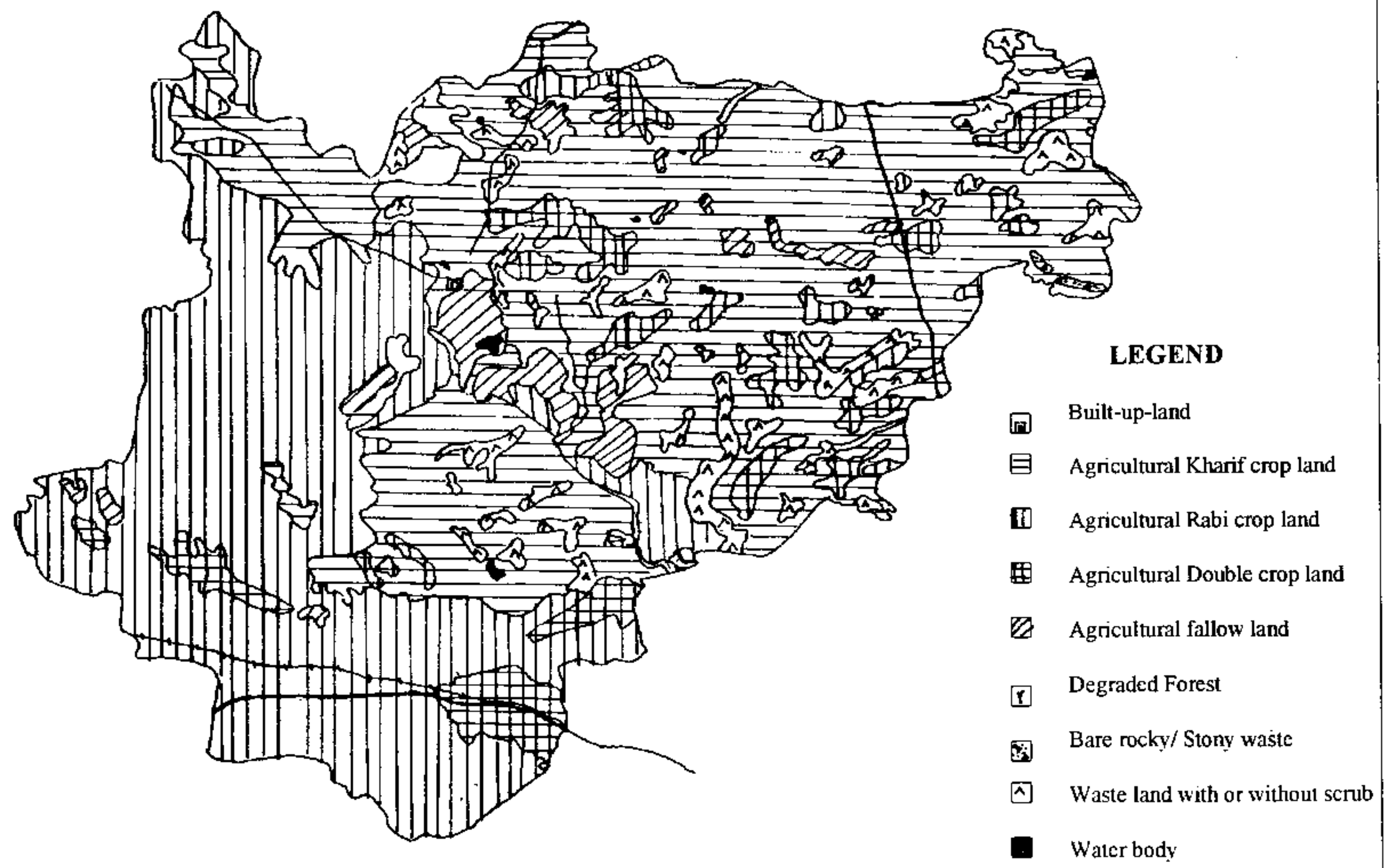


Figure 8. Landuse Map of the Yelberga Taluka in the Year 1989

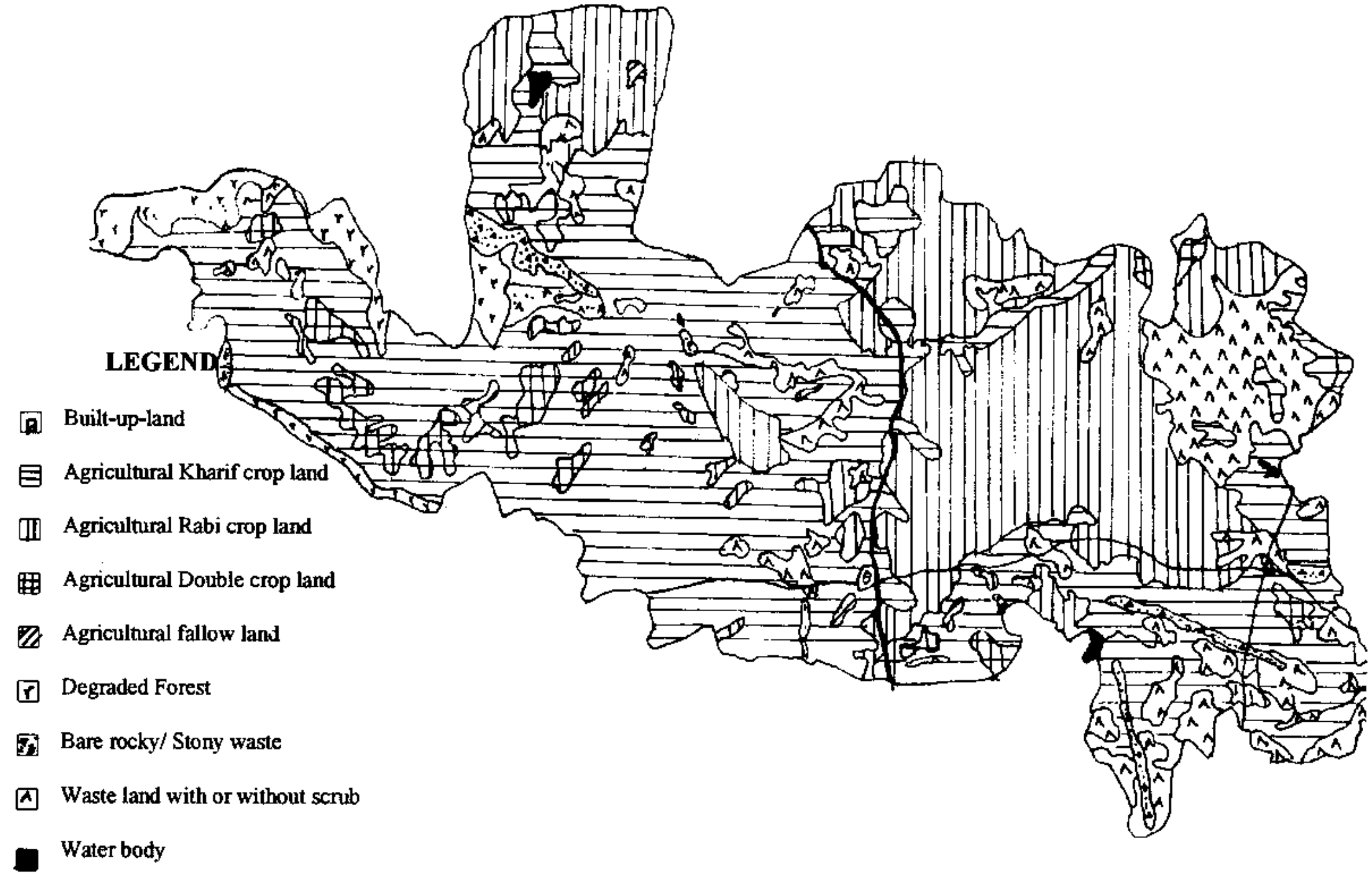
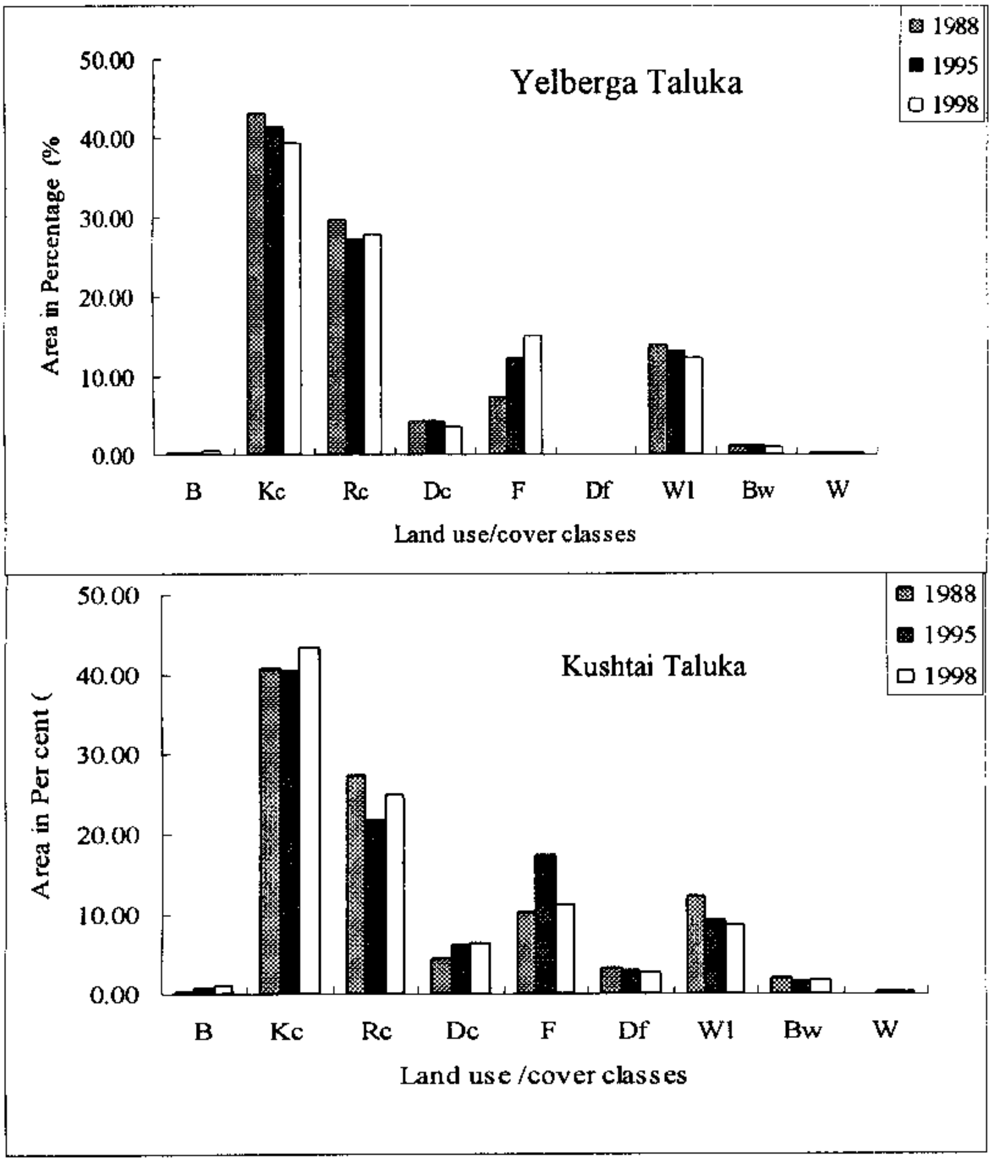


Figure 9. Land Use Map of the Kustagi Taluka in the Year 1989



NOTE:

B-Built-up-land,
Rc-Rabi crop land,
F-Agricultural Fallow
Wl-Land with or without Scrub
W-Water Body
Kc-Kharif crop land
Dc-Double crop
Df-Degraded forest
Bw-Barren Rocky/Stony Waste

Figure 10. Graphical Representation of Yearwise Percentile Coverage of Various Land Use/Cover Identified in the Study Area

Table 3. Yearwise Land Use/Cover details in the Yelberga Taluka

Sl.No.	Land use/cover	Year 1988		Year 1995		Year 1999	
		Area (ha)	Per cent (%)	Area (ha)	Per cent (%)	Area (ha)	Per cent (%)
1.	**Built-up land**	256.00	0.17	389.71	0.26	754.45	0.51
2.	**Agriculture land**						
	2.1. Crop land						
	(i) Kharif crop	63946.4	43.26	61328.6	41.49	58250.4	39.41
	(ii) Rabi crop	43963.5	29.74	39980.9	27.05	41163.2	27.84
	(iii) Double crop	6132.4	4.15	6320.0	4.28	5287.2	3.58
	2.2. Fallow	10843.7	7.34	18235.3	12.34	22242.9	15.05
3.	**3.1 Degraded forest**	0.0	0.00	0.0	0.00	0.0	0.00
4.	**Waste land**						
	4.1 Land with or without scrub	20551.0	13.90	19605.7	13.26	18294.54	12.38
	4.2 Barren rocky/ stony waste land	1876.0	1.27	1656.6	1.12	1377.87	0.93
5.	**5.1 Water body**	261.0	0.18	313.1	0.21	459.3	0.31

Table 4. Yearwise Land Use/Cover details in the Kustagi Taluka

Sl. No.	Land use/cover	Year 1988		Year 1995		Year 1999	
		Area (ha)	Per cent (%)	Area (ha)	Per cent (%)	Area (ha)	Per cent (%)
1.	**Built-up land**	281.00	0.19	1256.98	0.85	1620.13	1.10
2.	**Agricultural land**						
	2.1. Crop land						
	(iv) **Kharif crop**	60361.0	40.83	52944.9	40.55	64131.7	43.38
	(v) **Rabi crop**	40240.0	27.22	32066.1	21.69	36774.7	24.88
	(vi) **Double crop**	6334.0	4.28	8859.0	5.99	9296.1	6.29
	2.2. Fallow	15020.0	10.16	25529.7	17.27	16668.4	11.28
3.	**3.1 Degraded Forest**	4562.0	3.09	4317.51	2.92	4008.00	2.71
4.	**Waste land**						
	4.1 Land with or without Scrub	18086.0	12.23	31579.6	9.19	12517.8	8.47
	4.2 Barren rocky/ stony waste land	2778.0	1.88	2085.5	1.41	2425.8	1.64
5.	**5.1 Water body**	168.00	0.11	190.64	0.13	387.50	0.26

Table 5. Yearwise Normal and Actual Rainfall during Different Seasons/Months in the Study Area

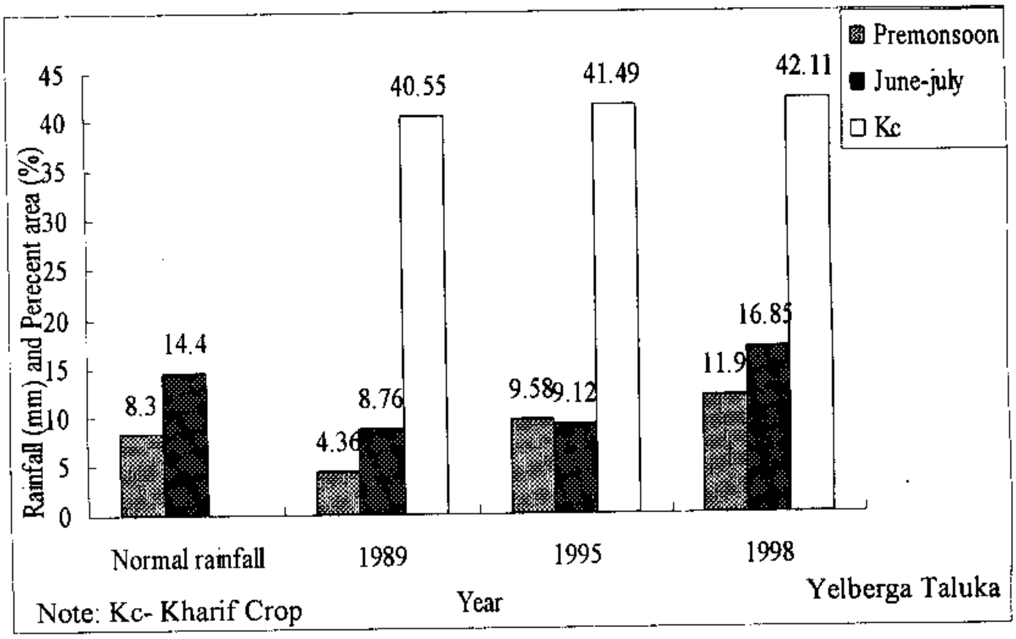
Sl. No.	Season/ Month	Rainfall (mm)						
			1989		1995		1998	
		Normal Rainfall	Actual Rainfall	Excess/ Deficit	Actual Rainfall	Excess/ Deficit	Actual Rainfall	Excess/ Deficit
Yelberga Taluka								
1	Pre-monsoon	61.0	140.1	79.1	118.6	57.6	18.0	-43.0
2	June-July	144.0	123.1	-20.9	160.1	16.1	66.1	-77.9
3.	August	103.0	31.4	-71.6	87.0	-16.0	135.8	32.8
4.	September	149.0	163.4	14.4	42.0	-107.0	253.0	104.0
5.	Post-monsoon	127.6	108.3	-19.3	133.0	-5.4	141.6	14.0
Kustagi taluka								
1	Pre-monsoon	83.0	43.6	-39.4	95.8	12.8	119.0	36.0
2	June-July	144.0	87.6	-56.4	91.2	-52.8	168.5	24.5
3.	August	77.0	19.8	-57.2	50.3	-26.7	59.0	-18.0
4.	September	142.0	152.4	10.4	48.4	-93.6	271.0	129.0
5.	Post-monsoon	140.9	96.0	-44.9	222.5	81.6	104.3	-36.6

Note: (-) indicates deficit of rainfall during the particular season/month and ( ) indicates excess of rainfall during the particular season/month.

data could be useful for the identification and delineation of the cropping area in different season. The Rabi crop land is identified and delineated from the IRS LISS II and LISS III data in the month of November to December and ground truth verification. From the table 3, it is found that there is some variation in the Rabi and Kharif season crop growing areas. This small variation may be due the rainfall and its distribution throughout the area. From the analysis of the monthly rainfall and its distribution, it is found that, some of year the rainfall is deficit as shown in Table5, which may affect the Kharif growing area. Since, the growing period for Kharif season is mainly depends upon the pre-monsoon rainfall as well as rainfall during June-July. This could be analysed from the comparison between the normal rainfall for these seasons and the actual rainfall during the years 1989, 1995 and 1998. The graphical representation of the normal rainfall and actual rainfall for different season/month for three years as above is shown in figure 11. From the figure 12, it is found that there are subsequent changes in Kharif crop coverage according to the rainfall variation during pre-monsoon and June-July. The total cropland is also affected due the temporal variation of the rainfall. The current fallow appears in light grey and yellowish blue tone and the long fallow land in dark gray to dark greenish tone with indistinct field boundaries in continuous patches in IRS imageries. From the table, it is found that there is increase trend in the agriculture fallow land. This is may be due to the low rainfall and quality of soil especially salt affected soil in some portion of the taluka, which can be clearly seen in the figure 4. Eventhough, most of area of the region is covered by agriculture, there is no much development found in the entire region. This may be due to scanty low rainfall as well as land productivity, which ultimately results into agricultural drought. The main crop found during the ground truth verification were sugarcane, maize and sorghum in black soil while groundnut, bajari etc in red laterite soil.

2. **Degraded forest**

This is found mainly in the hilly portion of the taluka and it is associated with basaltic terrain which, bordered to the taluka boundaries in northwestern direction. It is a portion of reserved forest in Kustagi taluka. Since, this category of land use is having very few coverage, there is no much changes during the last ten years (table 3 and table 4). In Yelberga taluka no such land use has been delineated may be due to very small coverage as well as high resolution of satellite data. The farm forestry or social forestry nearby rural settlement in the panchayat land may be merged with the agricultural land may be due to less coverage and high spatial resolution of the IRS data. Hence, it could not be identified and mapped.



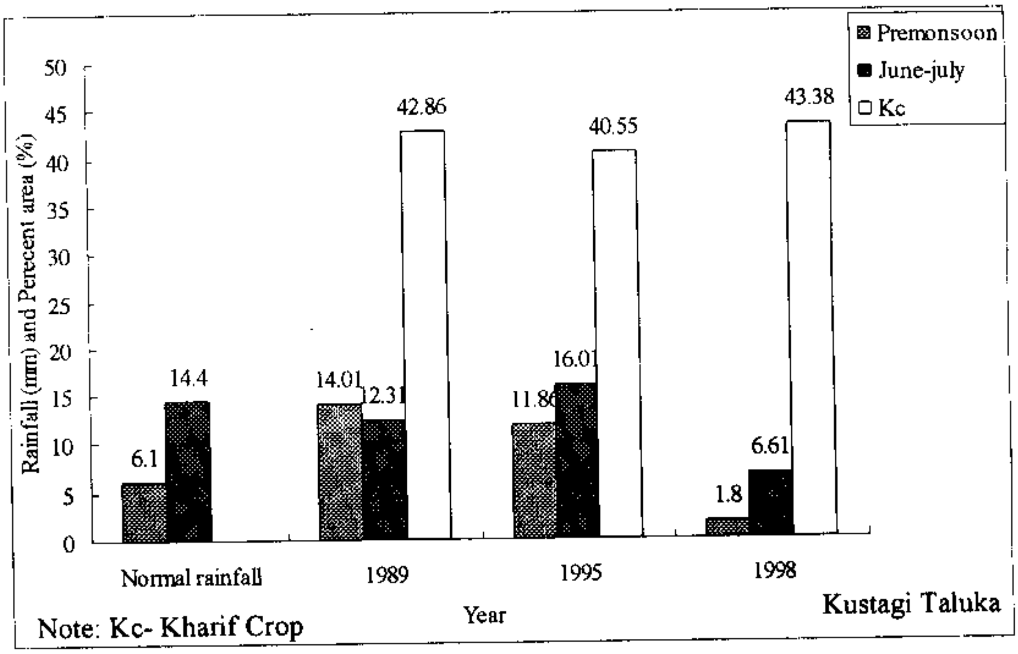
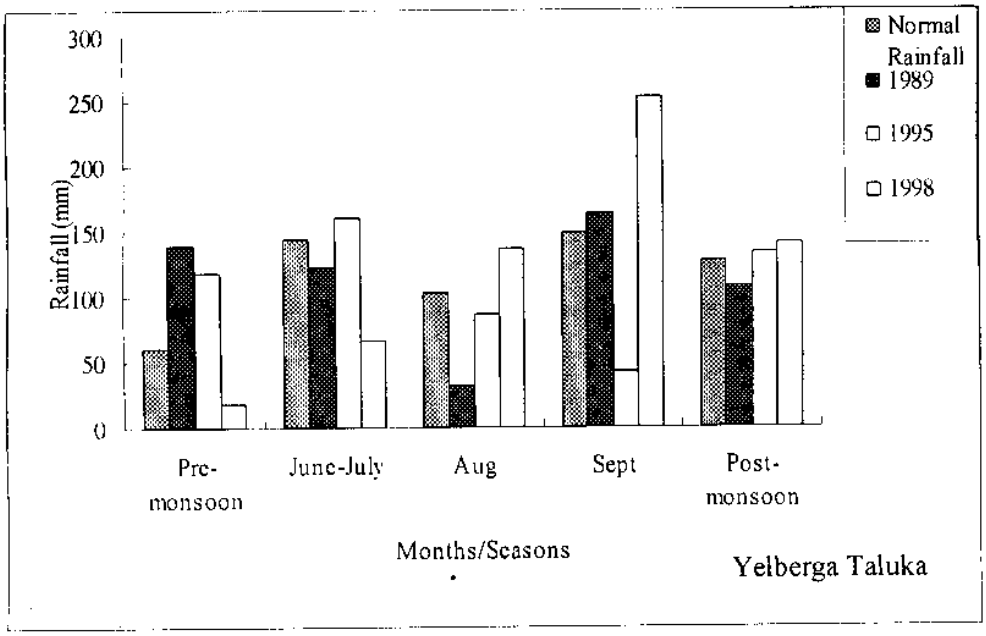


Figure 12. Yearwise Percentile Coverage of Kharif Cropland and Rainfall during Various Seasons/Months in the Study Area



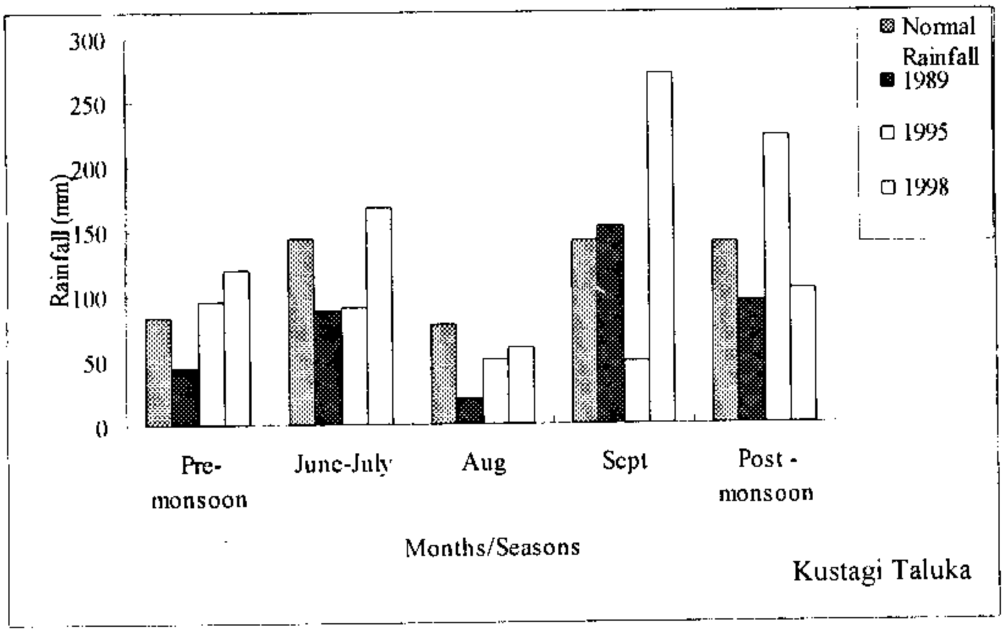


Figure 11. Graphical Representation Showing the Comaparision Between Actual and Normal Rainfall during the Various Seasons/Months for the Different Years

3. **Built-up-land land**

It is the area of human habitation developed due to non agricultural use and that which has a cover of buildings, transport, communication, utilities in association with water, vegetation and vacant lands. Collectively, cities, towns and habitations are included under this category. Their shape and high reflectivity differ initiate them from other classes. Due to high resolution of data, it is possible to delineate only the towns and cities. This category of land use/ cover, due to its tonal appearance and DN values could not clearly segregated from the Barren Rocky/Stony waste land. But, still from the table 3 and table 4, it is found that there is increase trend in the built-up-land. This may be due to increase population and urbanisation. The cities or towns, which were not identified earlier in the year 1989, are delineated clearly in the IRS LISS III images.

The semicompact and dispersed type of settlements could not be identified and may be merged with other land use type. But, due to the limitations of the spatial resolution of the sensor and scale of the available toposheet used for the georeferencing the IRS 1B, LISS II and LISS III data, only large and compact urban settlement and few roads and railways tracks could be identified and mapped. According to 1981 census the total population of the talukas living in rural and urban settlement were increased in the subsequent years.

4. **Barren Rocky/Stony Waste land**

This category of land use/ land cover comprises of sandstone, granite rocks and sheet rock and characterised by steep slope, boulders, cobbles and gravelly sand. These waste have been further degraded due to increasing biotic activities like cutting and looping of plants grazing and granite mining particularly in Kustagi taluka for the colouring and making tiles and stone mining for construction of house, roads etc. Greenish blue to yellow to brownish tone and high DN values in both visible red and infra red bands, it could be easy to demarcate and mapped. Due to similar or nearer spectral signature, it can be mixed with Built-up-land during the supervised classification through ILWIS.

The area of the large size of this category could be easily identified and delineated and mapped through IRS imagery. The unmappable small rocks outcrops and rocky/stony area were merged with the cropland and fallow land.

5. Waste land with or with out scrub

Due to sequential increase in human habitation and growing urbanisation, there is greatly affected in the punchayat as well as revenue recorded wasteland. Also, the human tendency to convert the wasteland into agricultural cropland, there is a substantial decrease in wasteland. Hence, the waste land which was previously recorded as 13.19 per cent of total geographical area of Yelberga taluka and 12.23 per cent of total geographical area of Kustagi taluka, now found to be equal to 11.36 and 8.47 per cent respectively.

The rocky gravelly flat surfaces with shallow soils in the pocket and devoid of vegetation exhibits whitish gray to gray tone while, the area with vegetation appears in light red to greenish brown and dark tone as shown in the extracted view of the taluka.

6. **Water bodies**

In the taluka area, number of small and large size lakes as well as tanks are found. In addition to these water bodies there are number of village ponds of small and medium size. But due to the scale and resolution limitations of Topo sheet, it could not be delineated. From the multidate IRS LISS II and LISS III data, it is somewhat possible to demarcate all the water bodies as possible. The temporal changes in the water- spread area could be function of rainfall distribution. The annual rainfall for the year 1998 is more than average annual rainfall of the region. This could be one of the reasons for increase in the area of water bodies for the year 1998. The new water bodies emerge out due to human interference, which also increase the water- spread area. Therefore, the information regarding these new water bodies as well the possible surface water potential will help in the planning of the any water resource project in the this drought affected area.

This class of land use is distinctively visible in elongated and semi-circular shape, scattered and non-contiguous patches and in light blue to dark blue tone on the IRS imagery. The graphical representation of the water spread area and total rainfall during the different years is shown in figure 13. It is generally found that there is direct relationship between rainfall and water spread area. Also the spatial resolution of LISS III camera, it could identified the smallest water body as compare to LISS II camera. In the monsoon season about 95 per cent of the total rainfall occurs in a short period of 3-4 months i.e. June to September. This rain occurs in the form of heavy showers with raindrops on an average 10 times bigger the rain drops in mid latitude country. Seven to eight month of the

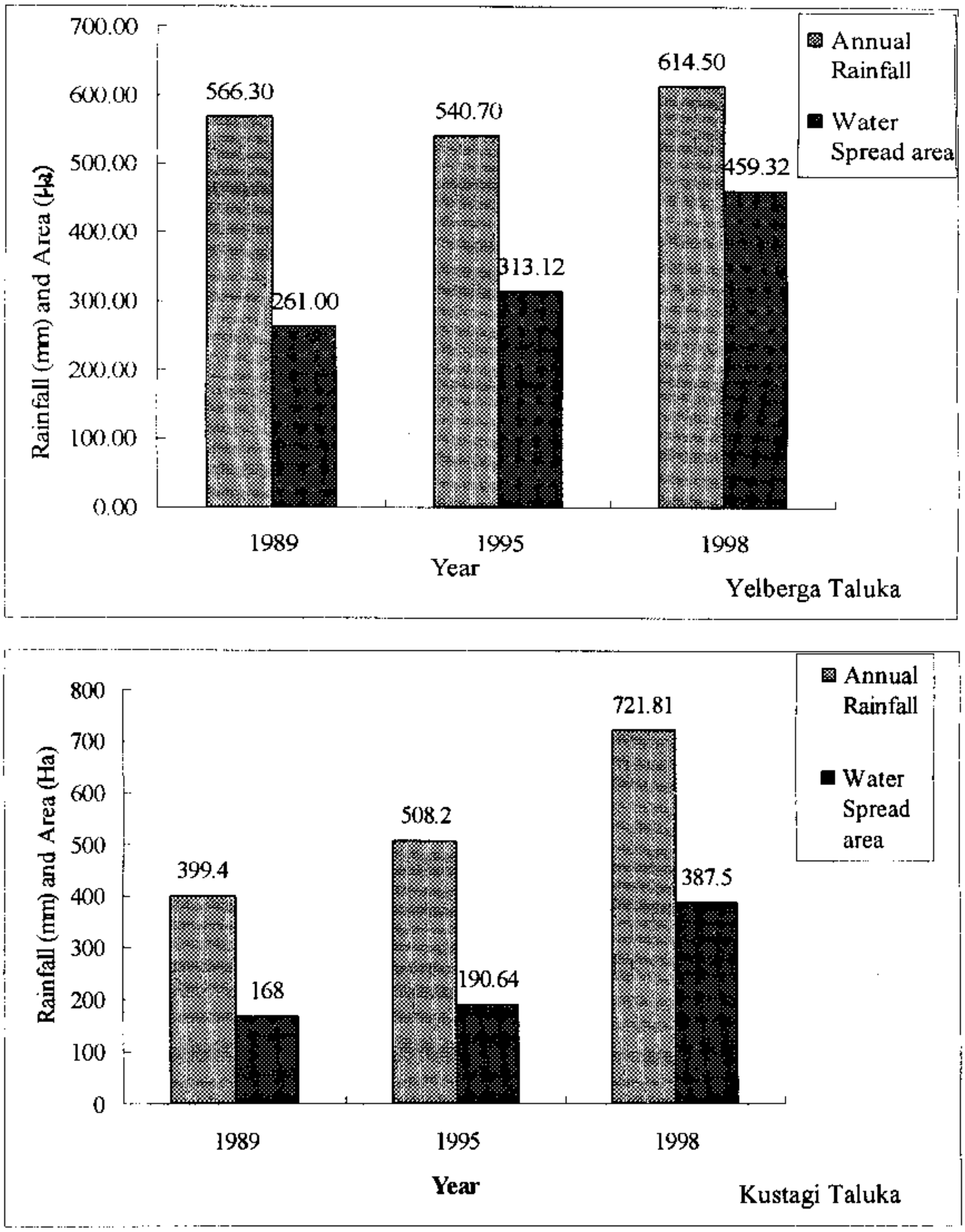


Figure 13. Graphical Representation of Water Spread Area and Annual Rainfall

years the region is rainless. Therefore, although the rainfall is sufficient, almost 60 per cent of it is wasted as runoff and converted into drought prone region.

Yelberga and Kustagi are also the drought prone regions. Drought is a major catastrophe, which often affect the economy of the region. It is a recurring climatic condition and affect agricultural production. Water harvesting is usually employed as an umbrella term describing a whole range of methods of collecting and concentrating various forms of runoff. Most water harvesting system use water only near where it falls, moving of water in small and large reservoirs. Thus by harvesting the runoff into small and large reservoirs for further irrigation, it is somewhat possible to mitigate the drought. In the drought prone area, surface water has an equally important role as ground water. Since, the study area comes under the hard rock region; the possibility for recharging the water table for irrigation is very less. Hence, the need for collecting and utilizing the surface water for life saving irrigation and other purposes have prime importance. Thus, monitoring the changes in water spread area will help for the estimation of surface water and further in the water balancing and planning of the cropping pattern for the region.

The drought monitoring and its prediction mechanism exist in the country based on observed rainfall and climatic parameters. Since, these method suffer from timeliness, variability and adequacy, the National Agricultural Drought Assessment Monitoring System (NADAMS) based on remote sensing method was developed at NRSA, Dept. of Space and is being operational since 1989. In order to evaluate the satellite-based parameters with drought the comparison study between remote sensing based vegetation index and ground information on rainfall with major crop yield. Normalized Difference Vegetation Index could be found helpful to identify the drought like agricultural drought studies. The NDVI is the ratio of reflectance between infrared and red bands. The NDVI parameters, i.e. Mean NDVI, Gross NDVI, Average NDVI, Area under Vegetation and % of cloud could be useful for drought indicators. NDVI is always positive for vegetation, while it is negative for non-vegetation. The average NDVI for the year 1995 and 1998 for the Yelberga and Kustagi are given in table 6.

Table 6. Average Normalised Difference Vegetative Index (NDVI) values

Sl. No.	Name of Taluka	Average NDVI values			
		1995		1998	
		Pre-monsoon	Post-Monsoon	Post-monsoon	Post-monsoon
1	Yelberga	0.048	0.119	0.062	0.115
2	Kustagi	0.055	0.125	0.075	0.129

7.0 CONCLUSION

In the present study land use/cover and water spread area maps for Yelberga and Kustagi talukas of Koppal district in Karnataka State have been prepared by using the digital interpretation of the IRS satellite data and ILWIS software. Five major land use/cover categories have been identified from the IRS satellite data for the years 1988, 1995 and 1998 as per the spectral, radiometric and spatial variation as well as the tone/colour, shape, size, texture, pattern, location and association of the particular feature. These land use/cover are built-up land, agriculture land, forest, waste land and water bodies. The dominant land use in the study area is agricultural cropland. From the data analyzed for the different years 1988, 1995 and 1999, it is found that, there is subsequential increase in built-up land. The town/city, which was not able to delineate in the FCC or satellite data of the year 1989 and 1995, could be delineate from the satellite data of the 1998. It seem that the geographical area of the town/city is increasing due to growing population, which ultimately affects punchayat waste land or public land and some extent to agricultural land. It is also found that there is increase in total agricultural land, it may be due to the conversion of the culturable waste land into crop land by removing the spreaded cobbles and boulders as well as rocky outcrop from the field area. Since, to satisfy the demand of growing population for food, it is necessary to increase the food growing area, which ultimately affect the wasteland extension. Recently, the granite mining in some patch of area also affects the land uses exist in the year 1989.

From the results obtained through the analysis of the data, It is found, eventhough the area is occupied with 85-90% of agricultural land use, there is no much development and status of economy. This may be due to the low productivity level. To have better productivity water is the prime importance, for which the in-situe- moisture conservation as well as the surface water efficient harvesting and utilisation are very essential.

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