IDENTIFICATION OF LAND USE AND LAND COVER CATEGORIES IN EASTERN DOON VALLEY AREA BASED ON REMOTELY SENSED DIGITAL DATA AND GIS TOOLS

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Abstract

Remotely sensed digital data provides a tremendous opportunity to identify land use types and land cover categories particularly when analyzed with the help of GIS tools in Eastern Doon valley area. In this study, an attempt has been made to identify land use types and land cover categories in terms of imprints of human activities such as agriculture, forestry and building construction that have altered land surface processes including hydrology and over all physical social and cultural environments. Information from the various editions of the Survey of India, Topographical map along with the IRS-1C and 1D LISS-III and PAN data have been used for initial thematic layer preparation and then through the Ground Truth collection the final land use and land cover map have been prepared. The major land use and land cover categories identified in this study are - cultivated land, fallow land, open forest, dense forest, plantation, settlement, water body, waste land, barren land, and aerodrome.

Keywords: *Subcontinent, environment, remote sensing, hydrology, digital Image, transformation, boundary.*

Introduction

The invention of Remote Sensing and GIS has opened new vistas in the field of geoscientific studies; viz. land use and land cover mapping, landform mapping, geological mapping, ground water targeting, mineral exploration, geo-hazard studies etc. The use of aerial photographs and satellite imagery is known for visualizing the landscape since time immemorial. The synoptic view provided by the satellite imagery helps in understanding and correlating various landforms, which cannot be readily observed from the ground due to limited range of observation (Graeme, *et* al, 1993). The last decade has seen a phenomenal growth in the use of Remote Sensing and GIS technology in land use and land cover studies as the land has become the most sought-after natural resource by the mankind due to tremendous pressure on the land use practices by the ever-increasing population and industrial growth (Hemphill, 1985).

Lack of adequate suitable space for settlement and industrial hubs inhibits the progress of developing countries and is the cause of considerable hardship to humans worldwide. A thorough geographical understanding is often critical for cost-effective land use model development projects designed to alleviate these hardships. Since last decade, the value per unit of land has outpaced the value of a barrel of oil in many areas of the world. Therefore, importance of a piece of land in various fields like domestic, industrial, agriculture and re-planning of land use requires an emphasis. Establishing relationship between Remote Sensing data and physico-cultural and socio-economic phenomenon can maximize the efficiency of utilization of land use development projects (Burrough, *et al,* 2000).

In spite of extensive research and technological advancement, the study of land use and land cover has remained more of a speculative and intuitive science, as there is no method to facilitate direct observation particularly in case of really remote and inaccessible areas. There are a number of factors that control the land use and land cover practices in a given area such as,

(i) Relief and topography
(ii) Landforms
(iii) Lithology
(iv) Soil
(v) Stratigraphy
(vi) Structure
(vii) Load bearing capacity
(viii) Gradient of slope, etc.

Remotely sensed data by virtue of its synoptic coverage and multispectral nature help in identification and mapping of most of the above factors with selective ground checks in a cost-effective manner. An integrated analysis of these factors along with the existing and available land use and land cover data in the GIS environment helps in identifying the land use and land cover categories for better utilization (Cromley, 1992). This helps in narrowing down the target areas for conducting detailed physical and socio-economic surveys on the ground, ultimately to find the boundary for delineation. Considering the importance of remote sensing and GIS techniques, the present study

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has been carried out in the eastern Doon Valley and its surroundings covering parts of Uttaranchal State with a view to map different landforms to understand geomorphic processes involved and to demarcate boundaries of land use and land cover units.

Objectives

The prime objectives of the present study are as follows:

1) To identify and map different land use and land cover units and understand the geophysical and socio-economic parameters involved.
2) To identify and map other parameters controlling the land use practices and land cover changes.
3) To correlate all the variables controlling changes in land use and land cover categories in the study area.
4) To suggest an ideal model of land use for sustainable growth and development in all spheres of local people concerned.

Study area

The study area covers eastern part of Doon valley and its surroundings having association with lesser Himalayas in the north, Siwalik Hills in the south, River Ganga in the Southeast and Dehra Dun town in the west. It covers about 740 sq. km area and is bound between 78º 05´N and 78º 25´E longitude, and 30º 05´ and 30º 30´N latitude. It falls in SOI Toposheet Nos. 53J/3, 4, 7 and 8 (1:50 000). The Doon Valley is an asymmetrical longitudinal synclinal Valley, which lies between two hill mountain ranges. The Lesser Himalayan mountain ranges lie in the north, and Sub-Himalayan (Siwalik) hill ranges in the south. Two major rivers of the Indian subcontinent, Yamuna, in the west and Ganga in the East form the boundary. The Valley has general elevation of 600m from MSL whereas the hills are as high as 2000m from MSL in the northeastern part of the study area. The Shon River, one of the tributaries of Ganga river system is considered to be the principle drainage system of the study area. The upper reaches of the Shon River is perennial whereas the lower reaches appear dry due to base flow. In lower reaches, the river displays braided pattern. Structurally controlled drainage is commonly seen in the study area. Drainage texture and patterns are controlled by different litho units, structure and morphology. In Siwalik region drainage pattern is sub-dendritic to sub-parallel and in pre-tertiary rocks, sub-dendritic pattern is seen. The hilly region is characterized by fine drainage texture and the Valley area by coarse texture. The area falls under sub-tropical monsoon type of climate receiving about 250 cm of rainfall annually. On the basis of rainfall intensity and temperature variations, the area is characterized by three distinct seasons – a) winter season from October-March, b) summer season from April-Mid June, and c) rainy season from Mid June to September. The major share of the total rainfall is received in rainy season. Thick forests cover is found in the major part of the study area. Sal is the common species. The piedmont zone is mainly utilized for plantation and agricultural purpose. The satellite imagery (PAN & LISS III merged FCC) have been visually interpreted to identify and map the various Land Use/ Land Cover of the study area.

Data used

The following data have been used in the present study:

1. IRS-1C/1D PAN & LISS-III data
2. SOI Toposheets (53J/3, 4, 7 & 8; Scale 1:50 000)
3. Land use and land cover data from the Department of Agriculture, Government of Uttaranchal, Dehra Dun.
4. Information collected during selective field checks.

Methodology

The methodology adopted in the present study is briefly described below:

Problem Identification

Land is more versatile, vital and abundant for the existence of all forms of life. With increasing demands on land by growing world population and increased modern industrial and agricultural activities, no natural resources has perhaps given rise to deeper concern about its over-exploitation and conservation, than good piece of land (Davis, 1986). There are immense possibilities of utilizing the modern techniques of remote sensing and GIS as an aid in land use and land cover survey. Considering the usefulness of remote sensing and GIS techniques coupled with the availability of data, approachability, etc, the eastern Doon Valley and its surroundings has been selected as study area for land use and land cover studies.

Pre-Field Study

The following procedure was adopted for preparing pre-field maps.

(i) Digital image processing, especially georeferencing, digital image enhancement and merging of PAN & LISS III data to improve visual interpretability.

(ii) Visual Interpretation of IRS-IC/1D (LISS III) & PAN imagery has been done of the study area for preparation of existing land use/land cover, geological structure and hydrology maps by taking the help of existing map and literature.
(iii) Preparation of base map with the aid of SOI toposheet Nos. 53J/3, 4, 7 and 8 (Scale 1:50 000) of Survey of India.
(iv) Data transfer on base map has been done in order to prepare the overlays of relief, topography, geologic and lithologic structure of existing land use/land cover etc.
(v) Selection of critical traverses for field checks.

Field Survey

The following procedure has been adopted during the fieldwork.

(i) Collection of existing land use/land cover data from Govt. Depts. (Department of Agriculture, Government of Uttaranchal).
(ii) Verification of land use/land cover, soil, lithological and geomorphological units, geological structures, etc. by taking traverses mainly along the roads.
(iii) Areal estimation of the existing land use/land cover in the field.

Post-Field Interpretation and GIS Analysis

The following procedure has been adopted in this stage:

(i) Correction of pre-field maps by incorporating field observations.
(ii) Tabulation of land use/land cover data and preparation of other related maps.
(iii) Preparation of slope map (amount and aspect) based on SOI topographical map.
(iv) Digitization of thematic layers.
(v) GIS analysis using index-overlay method for better and alternative land use planning.
(vi) Output generation and to reach at conclusion.

Digital Image Processing

Digital Image Processing is a collection of techniques for manipulation of digital images by computers. A digital image processing system consists of computer hardware and image processing software necessary to analyze digital image data (Jensen, 1996). Digital Image Processing is the numerical manipulation of digital data and includes preprocessing, enhancement and classification. Preprocessing refers to the initial processing of the raw data to calibrate the radiometric, geometric corrections and noise subtraction. Before starting the visual interpretation the IRS-1C/1D data have been georeferenced with SOI toposheets and then were subjected to digital image enhancements to improve the visual interpretability.

Geo-referencing

In a raster model, spatial data are organized in grid cells or pixels, a term derived from picture element. Pixels are basic units for which information is explicitly recorded. Pixels in a raster map have the same dimensions all over an individual unit of area (Lillisand, *et al*, 2000). Thus, it is unnecessary to store all their coordinates as the pixels are arranged in a regular pattern. It is enough to determine the pixel size and the parameters to transform between X and Y coordinates of a map and the pixel locations in the raster map (rows/lines and columns). The process to establish this relationship is called geo-referencing (Miller, *et al*, 1985). Through geo-referencing, we calculate the parameters used in the equations to transform between a coordinate system and pixel locations in the image.

Initially, the IRS PAN image was georeferenced with the Survey of India toposheet Nos. 53J/ 3, 4, 7, 8 (Map to Image Registration) using reference points in software used for this purpose (ERDAS IMAGINE 10.2). Subsequently IRS LISS-III data was co-registered with the already georeferenced PAN image (Image to Image Registration).

Digital Image Enhancement

Digital image enhancement produces new enhanced images which have better interpretability than the original image. In the present study, the following digital image enhancement techniques have been used.

1. Linear contrast stretching.
2. Histogram Equalization.
3. Principal Component Analysis.
4. Inverse Principal Component Analysis.
5. Decorrelation Stretching.
6. Ratioing.

Data Fusion

Data fusion (or data merging) is the process of combining, digital data by modifying the data values, using a certain procedure. Before starting the fusion process, the data should be properly co-registered. There are many fusion

techniques, which exist in literature, e.g. principal component transform, HIS transform, Brovey transform, etc (Sabins, 1996 and Weibel, 1990 and 1991). The IHS transform is commonly used for merging two data sets at different spatial resolutions.
In the present study, IRS PAN & LISS III data have been merged using HIS technique mentioned. This image, by providing the multi spectral information from PAN data, would be highly effective for acquiring an optimal image for most of the interpretations.

Land use and land cover categories identified in the study area

An area above the mean sea level is called land. According to Davis (1976), as circumscribed by the earth, the area of what is considered to be land is finite and fixed in place. Land uses are subject to control by people, whose numbers are not fixed, who have many needs, and who move easily. Most of the people's need for food, clothing, shelter and energy come from the land, as so many of their needs for the amenities are provided by fields, landscapes and forests. One important problem, common to many land use situations is lack of adequate governance i.e. lack of sufficient authority to organize, plan and manage.

Planning, for example, may be good but fails in application for several reasons, including lack of sufficient support by concerned people, inadequate finance, or inability to revise plans to meet changing conditions. Also common is the need to establish effective control over uses that may be needed to achieve successful land management. This often requires recognition of both public and private rights of ownership exercised in a desirable relationship and balance with land resources and people needs. To comprehend complex areas of knowledge such as land use, it is necessary to learn to recognize issues and problems that are basically similar although occurring in seemingly different contexts (Meyer, *et al*, 1994). Land surfaces, depending on the definition of what should be considered as land, can be measured accurately in units of area. They also can be classified readily in broad terms by geological or soil features or by climatological and related ecological-vegetative groupings.

Land use, which is inevitably viewed from the human standpoint, introduces a number of classification problems because particular purposes and viewpoints must be considered. These vary widely by location, ownership, kind of use, and specific land characteristics. Another concept important in land use, as in other areas, is recognition of a concern for posterity. When and where a society is strongly land based and has stable land tenure and inheritance, the idea of passing on an estate to one's heirs intact or improved is very strong and has long been so. Certainly, people normally have strong feelings of responsibility for their children and of loyalty for their societal group or country.

The satellite imageries (IRS-1C/1D PAN & LISS-III merged FCC) have been visually interpreted to identify and map the various land uses/land covers of the study area. The land use/land cover map (Figure-2).

The following land use/land cover categories have been identified in the study area:

1. Cultivated land,
2. Fallow land,
3. Open forest,
4. Dense forest,
5. Plantation,
6. Settlement,
7. River/Water body,
8. Waste land,
9. Barren land, and
10. Aerodrome.

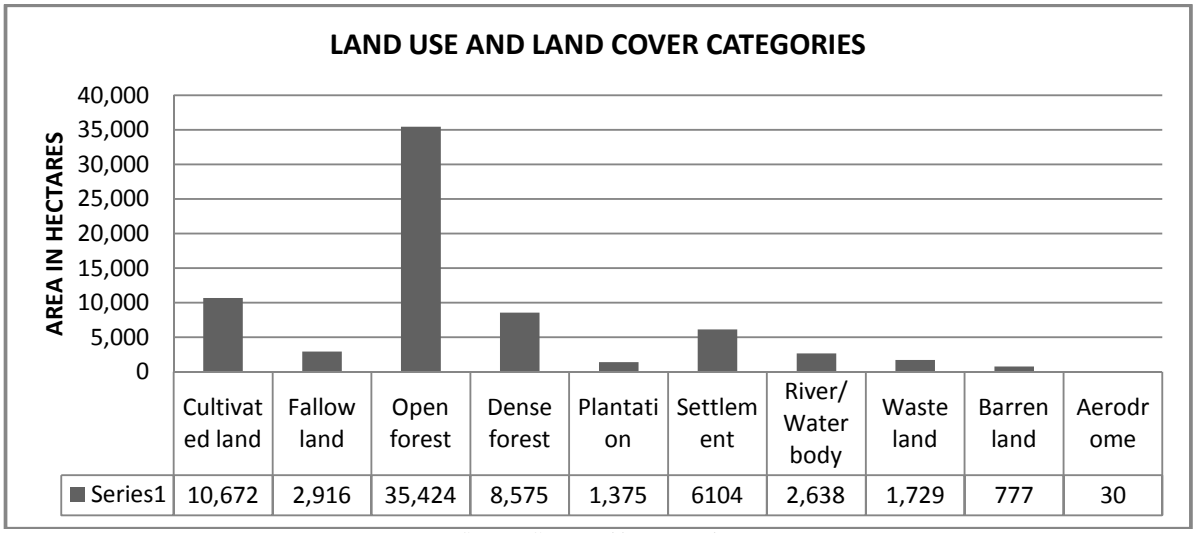
It is found that the open forest has shared most of the area. It covers an area of 35,424 hectares out of the total area of 70,240 hectares. Next to the open forest, cultivated land ranks in second position and occupies 10,672 hectares. Area under dense forest occupies 8,575 hectares. Next to the dense forest is the area under settlement, which covers an area of 6,104 hectares. A considerable amount of area is also under fallow land and covers an area of 2,916 hectares. Next to the fallow land is the area under river/water body, which occupies about 2,638 hectares area (Table-1).

Table-1, Areal extent of various land use/land cover categories in the Eastern Doon Valley area.

ID	*Land Use/Land cover*	*Area (hectares)*
1	Cultivated land	10,672
2	Fallow land	2,916
3	Open forest	35,424
4	Dense forest	8,575
5	Plantation	1,375
6	Settlement	6104
7	River/Water body	2,638
8	Waste land	1,729
9	Barren land	777
10	Aerodrome	30
	Total	**70,240**

Source: Computed by Researcher

Figure-1, Various land use and land cover categories in the study area.



Source: Computed by Researcher

Area under wasteland is 1,729 hectares. Next to wasteland is the area under plantation, which accounts for an area of 1,375 hectares (Figure-1). The barren land and aerodrome occupy an area of 777 hectares and 30 hectares, respectively. This map can be used as one of the inputs in the integrated analysis for preparing a new plan for land use/land cover categories. Based on the present land use map along with the data as presented in table 1, a prospective land use plan is to be prepared by the land use planners. An utmost care is needed for assigning the weightage value for similar categories of controlling parameters concerning the ground reality. Both the physical, social, economic as well as cultural factors are to be considered with proper weightage.

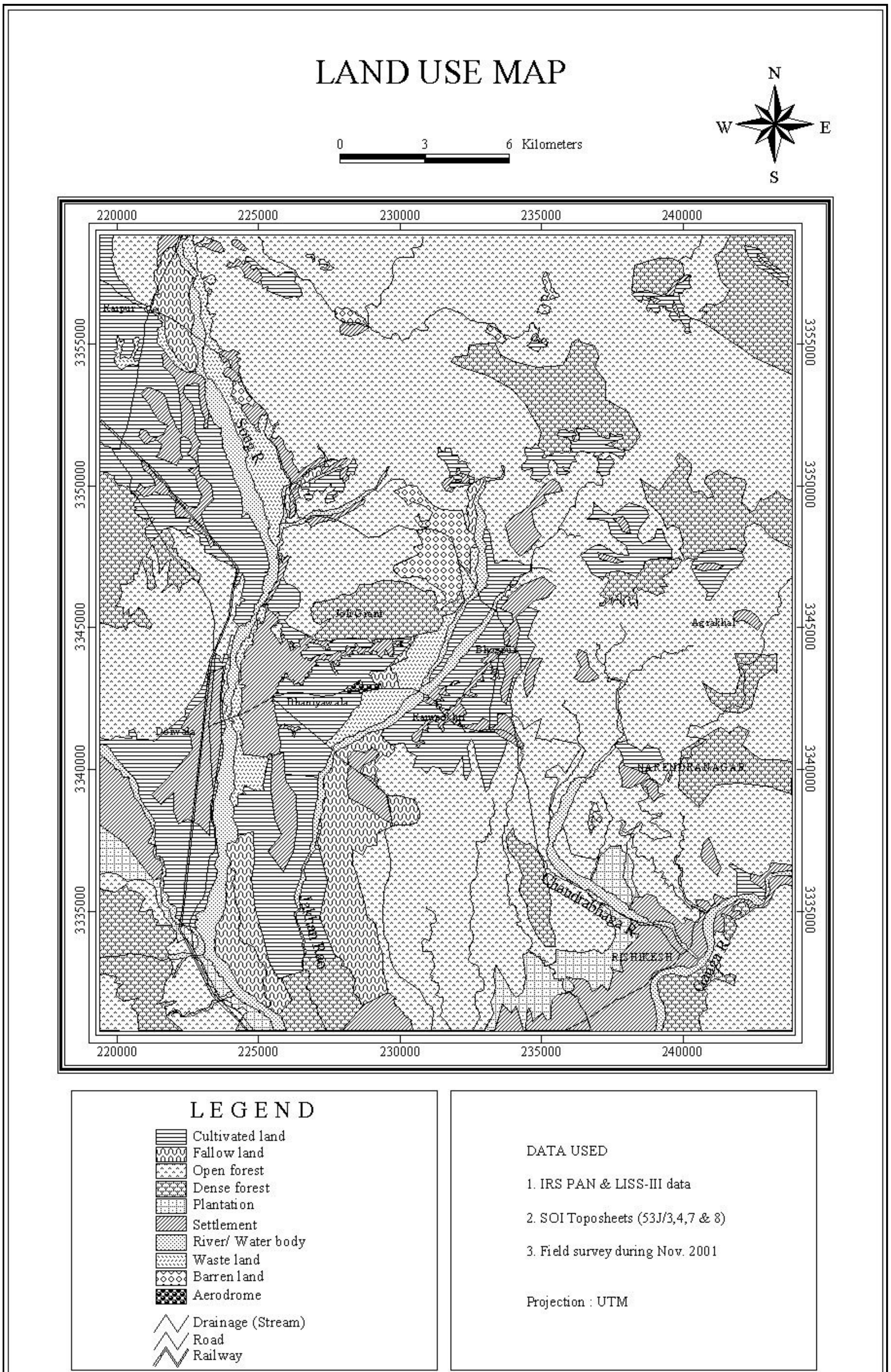

LAND USE MAP
0 3 6 Kilometers
N
W
E
S
220000 225000 230000 235000 240000
3355000
3350000
3345000
3340000
3335000
Song R.
Bhaniyawala
Agrakhal
NARENDRANAGAR
Chandrabhaga R.
RISHIKESH
Ganga R.
LEGEND
Cultivated land
Fallow land
Open forest
Dense forest
Plantation
Settlement
River/ Water body
Waste land
Barren land
Aerodrome
Drainage (Stream)
Road
Railway
DATA USED
1. IRS PAN & LISS-III data
2. SOI Toposheets (53J/3,4,7 & 8)
3. Field survey during Nov. 2001
Projection : UTM

Figure-2

Conclusion

In conclusion, it may be said that the transformation of land cover into land use is an age old practice throughout the world. In Doon valley area, the rate of transformation has increased many-fold since last three decades. The depletion of natural forest cover by human being causing so many irrecoverably damage to the bio-diversity and environment.

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