IDENTIFICATION OF LAND-USE AND VEGETATION TYPES IN FATEH JANG AREA, USING LANDSAT-TM DATA

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ABSTRACT

The study area has an undulating topography, with terraced land for agriculture and slopy and dissected patches under natural vegetation. The objective of the study is to valuate the capability of LANDSAT-TM data for identification of various land-uses and to differentiate the vegetation covers, like forest, crop, shrubs and grasses. The image classification was carried out through supervised and unsupervised classification techniques. In general, the trend of coverage of classes identified by both the techniques is the same. The contingency table indicates the accuracy of training-samples within range of 94 to 98 percent, used for the classification of image.

The NVI technique was used to separate the spectral reflectance of vegetation from background reflectance. It has improved the segregation of bare ground and vegetative areas. The coverage of water-bodies can be estimated by using any technique, since the reflectance of water is quite different from other landcovers except some shadow-areas. The effect of shadow-areas in the hilly terrain can be eliminated on micro-level considering their association with the surrounding landcover. Considering the spectral resolution of the RS data used, the technique has high potential for identification of various landcovers and land use. A combination of image analysis techniques with field survey of sample-sites will allow refining the boundaries of defined classes.

Key words: *Fateh Jang, Landuse, Agriculture, vegetation types, RS and GIS*

INTRODUCTION

Applications of Remote Sensing (RS) and Geographic Information Systems (GIS) in agriculture and natural resources are at initial stages in developing countries. The increasing population and shrinking resources are the driving forces for improving the planning-process. At present, the sound resource-management decisions increasingly require interpretation of large and complex datasets. GIS is now an accepted computer-age management-tool for resource analysis, planning and monitoring[2,3,5]. It provides a strong base for agricultural/natural resources planning and research; technology development, extrapolation and commercialization. The visual interpretation, in combination with digital interpretation of RS data is giving an opportunity to enhance the knowledge about the existing system, detect the changing trends and improve the planning process[6].

In some of the areas, native vegetation is replaced by semi-natural vegetation, because of the agricultural practices in the marginal lands and, in others, the agricultural lands are disturbed because of industrialization and urban expansion. In order to cope with the dynamic nature, a regular landuse or land-cover mapping and monitoring for planning and execution of development-programmes is required.

The conventional means of mapping land-use is not only time-consuming but also accompany high cost. Sometimes it is difficult to access rough and hard areas. Though there are some limitations in using RS data, depending upon the situation but, in general, because of its increased spectral and spatial domain, it can successfully be used for detection of landuse and land cover[6,7].

Land-use is dependent upon many variables e.g. land ownership, economics, climate, topography, soils, traditions, population, etc. Integration of at least some of these parameters with fieldwork, ancillary data and RS data, enables a realistic picture of the area to be drawn. It has been demonstrated that an accuracy level of 95%, compared to prescribed 85%, can be achieved in defining the land-cover/ land-use types, using RS data along with other supportive data[2].

The Fateh Jang area consists of different types of land-uses. The main landuse is rainfed agriculture. The non-cultivated area consists of natural vegetation like forest, shrubs and grasses and the wastelands. In the past a land-use study was carried out in the area, based on field surveys and other conventional means by the Soil Survey of Pakistan. The present study was carried out to see the potential of RS and GIS in identifying

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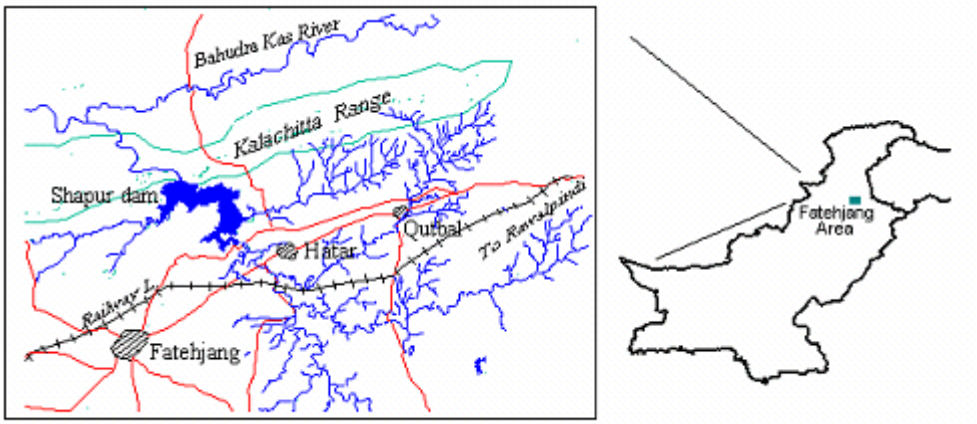

Figure - 1: Location Map of Study Area

the existing landuse and to separate the various vegetation types.

THE STUDY AREA

The study area lies in the districts of Attock and Rawalpindi, Pakistan, with a longitude and latitude range of 72° 38' 26" to 72° 50' 37" E and 33° 32' 7" to 33° 40' 7" N, respectively. It covers an area of about 19x14 sq. km (Figure-1). The area has an undulating topography, with terraced land for agriculture and slopy and dissected patches under natural vegetation. There is a mountain range that stretches from north east to north west of the study area, called Kalachitta Range. The soils are mainly silty and sandy loamy clay. Outcrops of limestone are also present in Kalachitta forest range. Climatically the area falls in sub-humid, warm subtropical monsoon region[1]. There are two distinct rainy seasons, one in summer (Kharif) with a peak in July-August and the other in winter (Rabi) with a peak in February–March. The mean seasonal rainfall in Kharif and Rabi seasons ranges from 300 to 500 mm and 250 to 300 mm respectively. The temperature ranges from 5° to 30° C.

AGRICULTURE AND LAND-USE

The agriculture in the selected area is mainly dependent upon the rainfall. Some surface-irrigation through wells is available primarily for fruits and vegetables. Wheat is the main Rabi crop, intercropped, in patches, with gram (Cicer arietinum), barley (Hordeum vulgare), taramira (Eruca sativa), sarson (Brassica campestris) and lentils. Millets (Pennisetum) are widely cultivated in summer, in addition to maize (Zea mays), groundnut (Arachis hypogaea), til (Sesamum indicum) and guara (Cyamopsis tetragonoloba).

The Kalachitta range is covered with trees and shrubs of semi-arid climate. The foothills are covered with patchy grasses. The forest includes trees like Olea cuspidate and Acacia modesta. Some plantations, of Eucalyptus, Poplar and Shisam are also found in the area. A. modesta is the dominant tree in the cropped area while other tree-species are found only on hilly tracts and foothills. Among shrubs Dodenia viscose and Ziziphus numularia are dominant. The grass species include Hetropogon contortus, Cynbopogon sp., Cynodon dactylon and Panicum antidotale. A part of the area is used for grazing and partly for fuelwood cutting. Due to overgrazing and cutting fuelwood, the health of the natural vegetation is deteriorating.

OBJECTIVES

The primary objective of the study is to develop a methodology for interpretation of LANDSAT-TM data using classification techniques and NVI for demarcation of various land-uses. The secondary objective is to differentiate the vegetation-covers, like forest, crop, shrub and grasses, using RS and other ancillary data.

MATERIALS AND METHODS OF DATA ACQUISITION

The image of LANDSAT-TM was acquired from SUPARCO, Pakistan. The image with row, path 37-150 has seven spectral bands. The spectral curves of some of natural features in relation to the seven

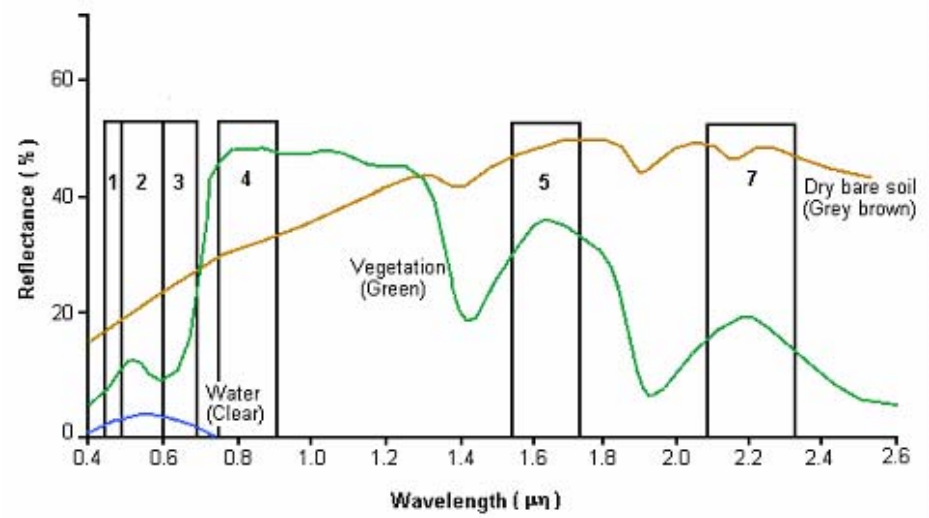

Figure - 2: Relationship between Spectral Curves of some natural features and the special range of the seven reflective TM-bands

Table - 1: Land-use classes identified by unsupervised-classification technique and their coverage

No.	Class	No. of Pixels	Per cent
1	Forests	14086	4.59
2	Crop land/shrub lands	78399	25.52
3	Grassland with rock outcrops	77260	25.15
4	Bare ground	132647	43.18
5	Water bodies	4808	1.56
	Total	**307200**	**100**

Table 2. Land-use classes identified by supervised-classification technique and their coverage

No.	Class	No. of Pixels	Per cent
1	Forests	33221	10.81
2	Crop land/shrub lands	66943	21.79
3	Grassland with rock outcrops	63393	20.64
4	Bare ground	138952	45.23
5	Water bodies	4691	1.53
	Total	**307200**	**100**

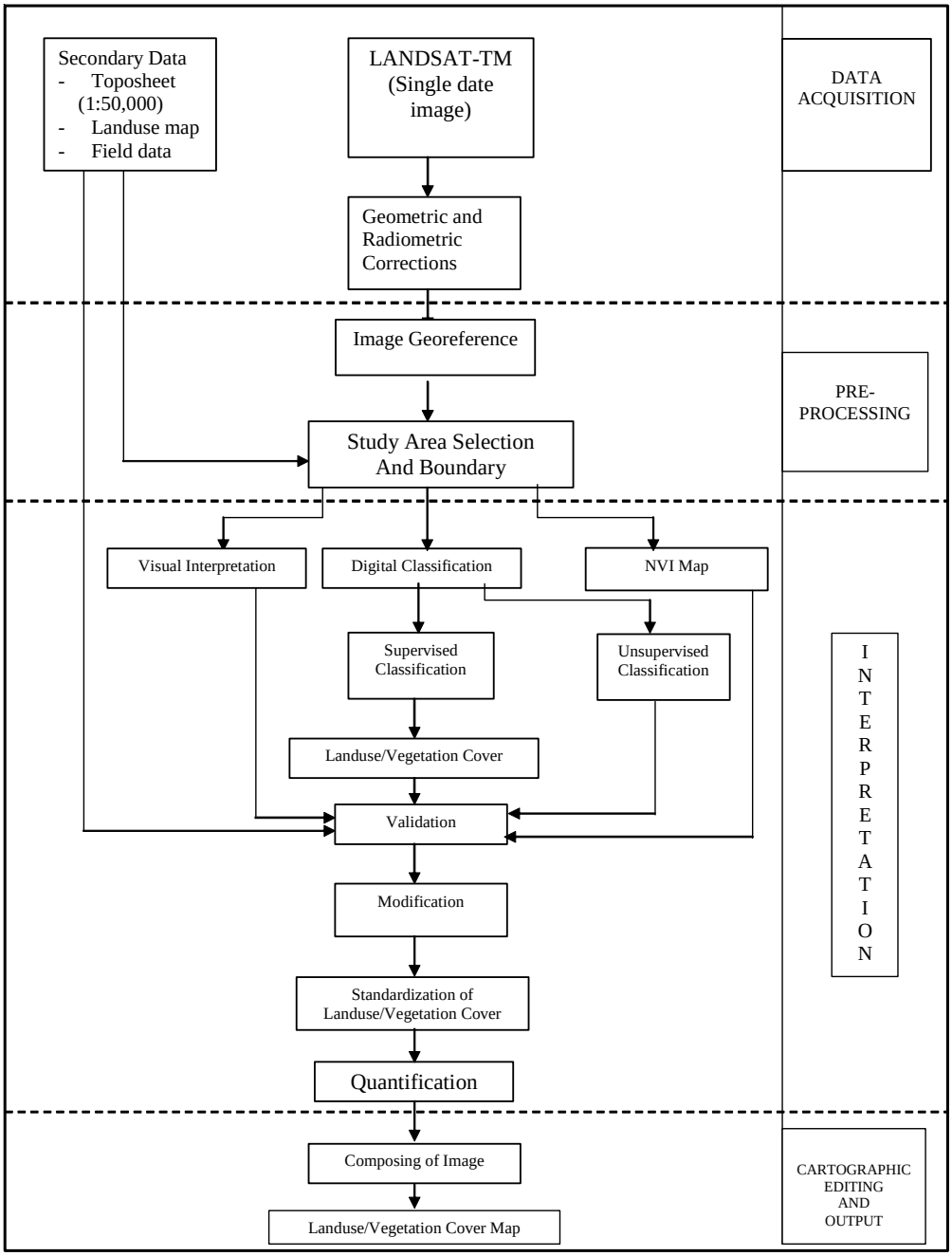

Figure - 3: Flow Diagram of Methodology Followed for Interpretation of LANDSAT-TM Data

spectral bands are presented in Figure-2. Band 4 and 5 could be used for identification of vegetation. The reflectance of bare-ground is maximum at band 5 and 7 and could be delineated using these bands. The band 2 can be used to delineate water-bodies, as it shows contrast between soil and water bodies. The other supportive data used include toposheets at a scale of 1:50,000, land-use map of Attock district, climatic data, and field data. The sources of these data-sets are Survey of Pakistan, Meteorology Department and Soil Survey of Pakistan.

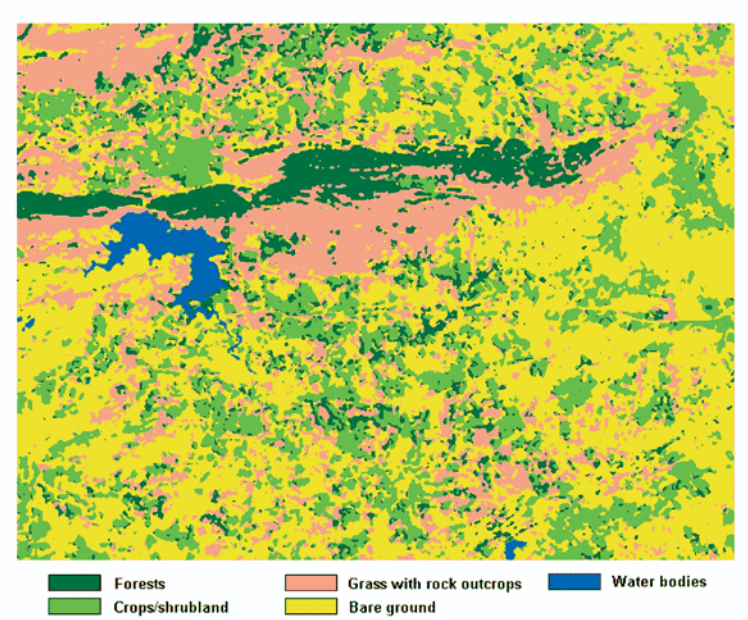

Figure - 4: Landcover Classes Identified for Fateh Jang Area through Supervised-Classification Method

METHODOLOGY

The flow diagram of methodology followed is presented in Figure-3. The image of the area was selected from the single LANDSAT-TM scene. The image was rectified, using the toposheets of 1:50,000 scales. The coordinate system followed was Universal Transverse Mercator (UTM). The field survey was carried out to collect data of ground-control points (GCPs) and different landcovers of the area, using Global Positioning System (GPS). As a first step, visual interpretation was done to identify ground-features on the basis of their tone/color, brightness, pattern, texture and shape/size, etc. The image was processed using the ERDAS GIS software for digital interpretation. The image classification was carried out through supervised (in combination with unsupervised) classification method. The objective of image classification is to link

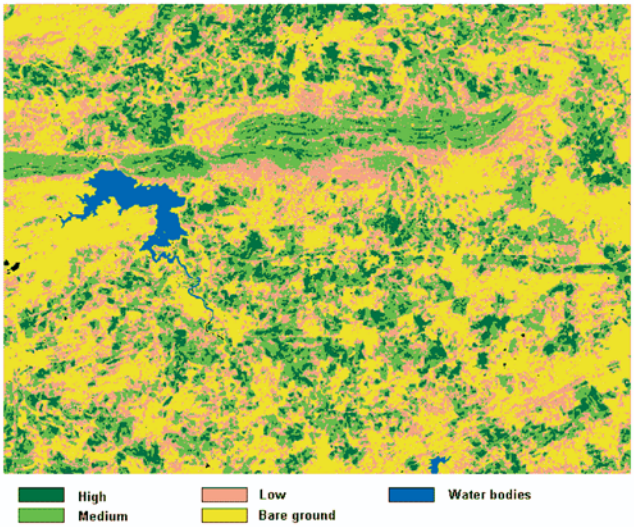

Figure - 5: NVI Map Indicating Density of Green Vegetation Cover in Fateh Jang Area

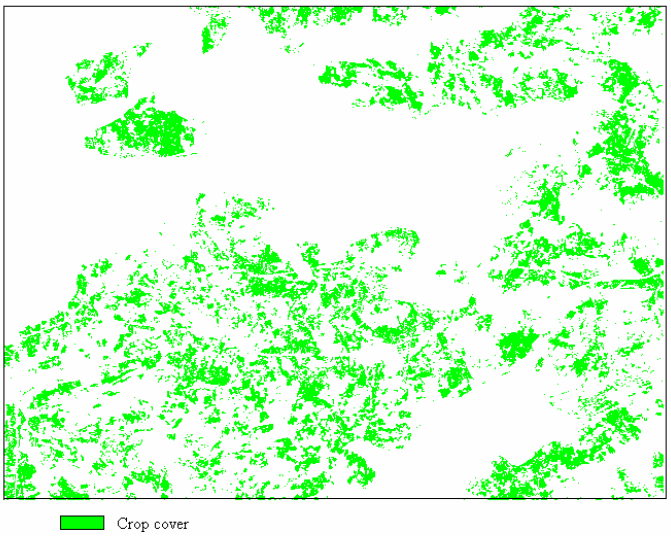

Figure - 7: Crop Cover Extracted from the Image of Fateh Jang Area

image-spectra to dominant scene components or to characteristic mixtures of components [4]. The unsupervised classification was used to develop classes identified by the computer on the basis of similar spectral characteristics of the group of pixels. This helped in defining more specific classes in the supervised method, in which training-sample sets were selected from the known areas on the image, to form set of signatures (statistical criteria for proposed classes) for classification. The signatures were evaluated using contingency matrix that shows whether or not there is an overlap among the pixels of training samples used for classification. The rule followed for the classification was "maximum likelihood" commonly used for reliable results. The classes were finalized after the removal of irregularities from the classified image.

The Normalized Vegetation Index (NVI) map was prepared from the image data. The NVI values give the density of vegetation-cover in the area. The NVI technique is used to separate the spectral reflectance of vegetation, such as crops, from background reflectance, like soil and water. To determine the NVI, band 3 and band 4 of LANDSAT TM are used as:

$$NVI = (TM4 - TM3) / (TM4 + TM3)$$

RESULTS AND DISCUSSION

Unsupervised Classification: The five landuse classes identified by cluster-analysis are forests, crop/shrubland, grassland with rock outcrops, bare ground and water bodies. The number of pixels assigned to each class is shown in Table-1. The extent of the class designated as bare ground is maximum (43.18%), which reflects the level of degradation in the area. The crop/shrubland and grassland with rock outcrops classes have almost the same coverage. The class crops/shrubland includes the cultivated area and some patches of natural vegetation, including shrubs and grasses. The reflectances of crops and shrubs are similar and could only be identified in context with the topography and infrastructure. This could further be refined after field validations. The class designated as grassland with rock outcrops is mainly grassland with gravelly soil and exposed rocks. The vegetation in this class consists mainly of grass species of degraded areas that are thinly distributed. The thin grass-cover in this class has the same reflectance as that of bare soil. On the other hand, the thick grass-cover has similar reflectance as that of the crops or natural vegetation. The water bodies are limited and the cover of 1.56% reflects mainly the pounded area of Shahpur dam. The forest covers about 4.6% of the study area. The forest class also includes some shadow areas on the hill slopes that give the same reflectance as that of thick tree-cover.

Supervised Classification: The classification was also carried out through maximum likelihood i.e. supervised classification (Figure-4). Table-2 indicates the extent of coverage of different landuse classes.

Table - 3: Image Contingency Table Indicating the Classification of Sample Pixels (Count and Percentages) to its Corresponding Signature Using Maximum Likelihood Classification

Signature Name	Training Polygon Names									
	Forest		Water		Bare ground		Crop/ shrubland		Grass with rock outcrop	
Forest	279	94.30%	1	0.10%	0	0.00%	23	3.60%	0	0.00%
Water	0	0.00%	1156	98.50%	0	0.00%	0	0.00%	0	0.00%
Bare ground	0	0.00%	0	0.00%	650	98.30%	1	0.20%	5	0.80%
Crop/shrubland	17	5.70%	2	0.20%	0	0.00%	615	95.30%	6	1.00%
Grass with rock outcrops	0	0.00%	15	1.30%	11	1.70%	6	0.90%	596	98.20%
Total points	**296**		**1174**		**661**		**645**		**607**	

Table - 4: NVI Classes and their Coverage

No.	NVI Classes for vegetation cover	No. of Pixels	Percent
1	High	30293	9.86
2	Medium	86712	28.23
3	Low	75794	24.67
4	Bare ground	109752	35.73
5	Water bodies	4649	1.51
	Total	**307200**	**100**

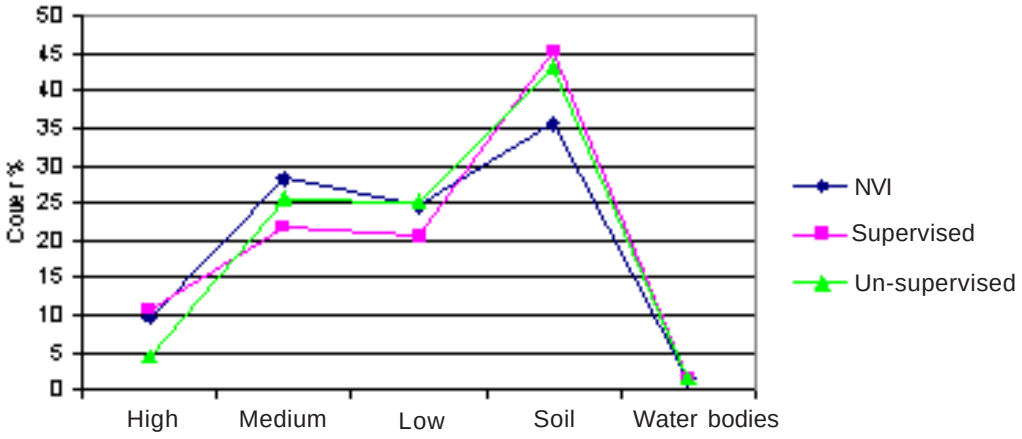

Figure - 6: The Correlation of NVI Classes with Image Classified Maps

Compared to unsupervised classification, in general, the trend of coverage of various classes is the same; but forest cover in supervised classification is almost double of that in unsupervised classification. (The portion of forest class having similar reflectance with other vegetation classes is classified into those classes in unsupervised method). In general, the forest in the study area is not in a very healthy state, due to stress of overgrazing and fuel woodcutting. The extent of cropland/shrubland and grassland with rock outcrops classes identified through supervised method is 26 and 25% respectively. The cropland/shrubland is found distributed in various parts of catchment and command areas of the Shahpur dam. The grasslands with rock outcrops are mainly found near foothills of Kalachitta range, gullied land and some wastelands. The extent of water-bodies is very close in both the techniques.

The contingency table indicates that the accuracy of training-samples, used for the classification, ranges from 94.3% to 98.5%, which is quite high, compared to recommended level of 85% (Table-3)[2]. The water-bodies and bare-ground classes have a higher level of accuracy, since these two classes can be segregated easily.

NVI Classes: The NVI map developed for the area shows various densities of vegetation cover from high to low and the non-vegetative area i.e. bare soil (Figure-5). The coverage of three vegetation-zones, namely high, medium, low, along with bare ground and water-bodies identified is given in Table-4. The high-density green cover shows the thick forest cover. The medium-density green-cover class corresponds to crops and shrub-lands, while low-density green cover is an indicator of sparse vegetation, like grasses, stunted shrubs, bushes, etc. The NVI has improved the segregation of bare ground and vegetative areas. The coverage of bare ground was decreased from 45.23% to 35.73% and this reduction added the area to crop/shrub land (6.87%), compact soil/grassland (4.41%) and forest area (0.8%). The extent of classes, like forest-cover and bare soil, can better be identified by NVI technique, since the results are quite close to those achieved by supervised classification (Figure-6). To identify the land- uses, like crop/shrubland or compact soil/grassland, the results of NVI and unsupervised classification techniques are quite close. The coverage of water- bodies can be estimated by using any technique, since the reflectance of water is quite different from other landcovers, except some shadow-areas due to mountain slopes.

The crop cover was extracted from the other natural vegetation cover, using the previous landuse boundary map. The crop-cover was estimated as 17% in the study area, as shown in Figure-7. The area other than cropland includes forests, rough grazing-land, rock outcrops, gullied land, hill slopes, etc. The state forest covers 4.2%, while additional 6.5% area is under private forest/plantations. Other natural vegetation i.e. shrubs/grasses, covers only 4.6% of the area.

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