Quickbird 영상을 이용한 객체지향 및 ISODATA 분류기법기반 토지피복분류-세부레벨계획을 위한 비교분석

Mapping of land cover using QuickBird satellite data based on object oriented and ISODATA classification methods - A comparison for micro level planning

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Abstract

This article deals mainly with two objectives viz, 1) the potentiality of very high-resolution (VHR) multi-spectral and pan chromatic QuickBird satellite data in resources mapping over moderate resolution satellite data (IRS LISS III) and 2) the advantages of using object oriented classification method of eCognition software in land use and land cover analysis over the ISODATA classification method. These VHR data offers widely acceptable metric characteristics for cartographic updating and increase our ability to map land use in geometric detail and improve accuracy of local scale investigations. This study has been carried out in the Sukkalampatti mini-watershed, which is situated in the Eastern Ghats of Tamil Nadu, India. The eCognition object oriented classification method succeeded in most cases to achieve a high percentage of right land cover class assignment and it showed better results than the ISODATA pixel based one, as far as the discrimination of land cover classes and boundary depiction is concerned.

Introduction

Natural landscapes and man-made constructions are dominated by textures and colors that reflect the diversity of the factors influencing the final sight of the surface objects (Musick et al., 1990). Till recent times, the classification of land cover was based on traditional pixel-based methods (Ahmad et al., 1997; Hayder et al., 1999; Menges et al., 2000). The land cover may be misclassified if they are spectrally similar but compositionally different. Similarly, the spectral heterogeneity of the land cover can lead to rogue pixels appearing within classes creating a 'salt and pepper' effect (Whiteside, 2000). In addition to this, the increased application of higher resolution imagery is problematic as it is difficult to classify accurately using traditional pixel-based methods. The increased amount of spatial information often leads to an inconsistent classification of pixels.

Most classification algorithms are based on the digital number of the pixel itself and/or texture attributes in a certain defined vicinity around a pixel (Landgrebe et al., 1976). Typical objects in an image are not characterized by one color, but by a characteristic texture of colors, as well (Steinnocher, 1997). At the same time the same color can be part of the texture of different classes of objects. Furthermore, it is very difficult to integrate context information in pixel-oriented approaches. Topology and spatial relationship features are also missing.

The spatial resolution of the operational systems (Landsat TM, Spot HRV, IRS) are applicable to the investigations on the regional scale (1:50.000). The new sensor generations with an improved geometric, spectral and radiometric performance like the airborne imaging spectrometer instruments (AVIRIS, MAIS, DAIS, CASI, etc.) or the spaceborne IKONOS and QUICKBIRD systems allow a mapping scale of 1: 10.000 and better. The performance of these sensors is key capability required for site specific micro level assessment and planning. However, acquiring maximum benefit from these resources will require research involving not only improved data analysis approaches, but also development of tools for the manipulation of such data

The object-oriented classification methods suitable for medium to high resolution satellite imagery provide a valid alternative to 'traditional' pixel-based methods (Baatz et al., 2004; Benz et al., 2004). Object-oriented classification involves segmenting an image into objects (groups of pixels). These objects have geographical features such as shape and length, and topological entities, such as adjacency and found within, (Baatz et al., 2004). Its classification phase starts with the crucial initial step of grouping neighboring pixels into meaningful areas, which can be handled in the later step of classification. Such segmentation and topology generation must be set according to the resolution and the scale of the expected objects. By this method, not single pixels are classified but homogenous image objects are extracted during a previous segmentation step.

While there has been some studies comparing object-oriented and pixel-based classification techniques little has been conducted in India. Most papers claim that object based classification has greater potential for classifying higher resolution imagery than pixel-based methods (Willhauck et al., 2000; Mansor et al., 2002; Oruc et al., 2004). Neimeyer and Canty (2003) claim that object-oriented classification has greater possibilities for detecting change in higher resolution imagery and Manakos et al. (2000) found that the ancillary data utilized within object-oriented classification is advantageous in improving the classification.

This paper compares the results of an object-oriented classification to unsupervised and supervised pixel-based classification for mapping land cover using QUICKBIRD satellite data in part of the Eastern ghats of India.

Study area

Sukalampatti mini watershed (4B1B2c5) has been selected for the present study. This watershed is situated at the eastern side of Kolli hills, Eastern ghats of Tamil nadu, India. Geographycally, it is situated between 11° 18' 10" to 11° 22' 00" N and 78° 24' 10" to 78° 29' 00" E, covering an area of about 2255 ha. For this study a portion of forest area covering 120 ha and a portion non-forest area covering 95 ha have been selected (Figure 1a, b). The altitude is ranging from 200 to 1200 m above MSL.

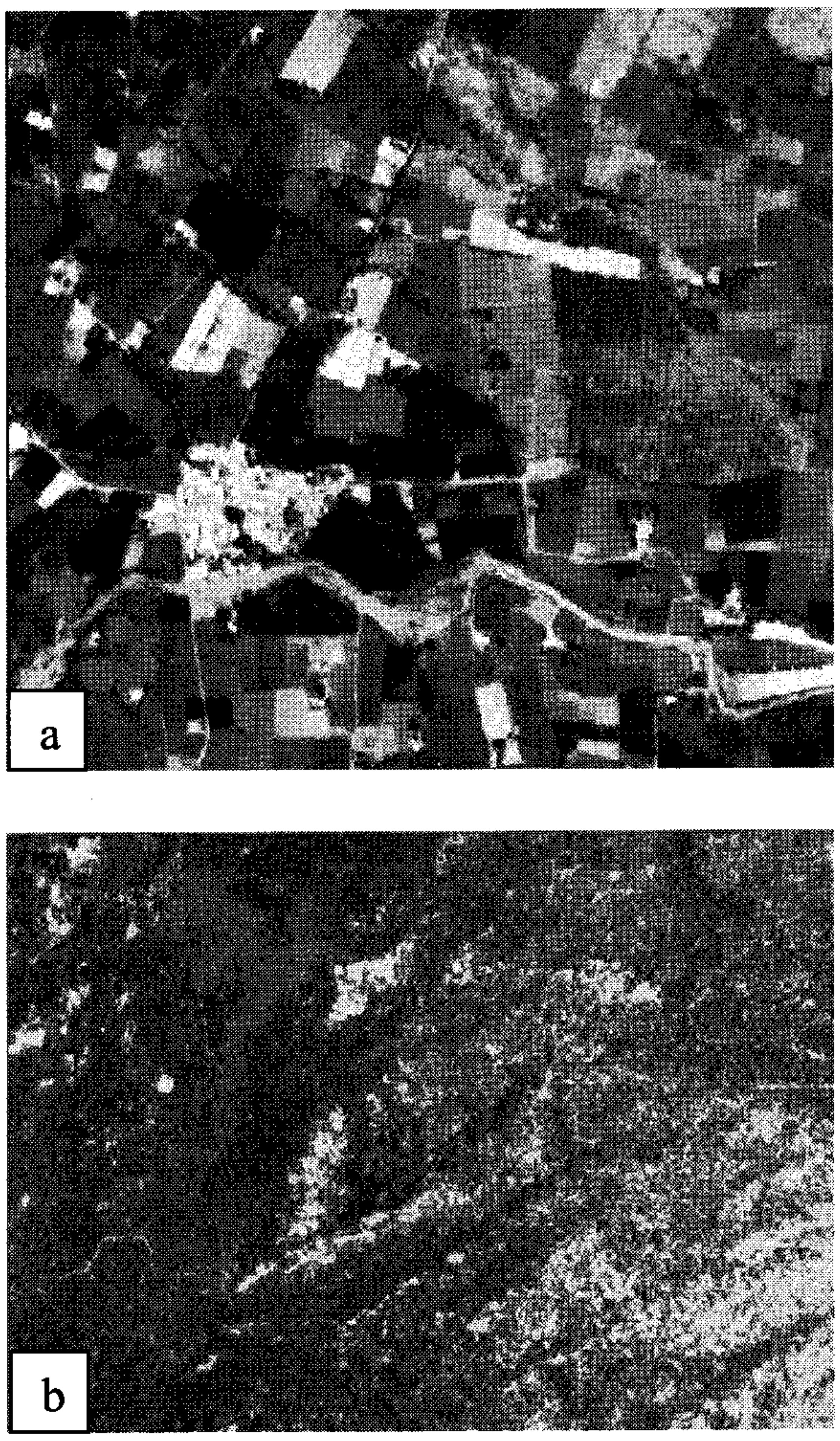


Figure – 1. False color composite (FCC) of QuickBird satellite data, Band combination 4,3,2 in RGB, a) Non-forest area, b) Forest area

Geologically, it is occupied by acid charnockite. The study area comprises plateau, valley and foothill. Tivattipatti and Pallikadu villages are situated in the plateau region and Sukkalampatti village in the foothill. Patches of deciduous, southern thorn and scrub forests are major forest types situated in the valley. Major portion of area belongs to forests. Agriculture is the main source of income of the people. Paddy, tapioca, pineapple and banana are grown in this area, however, the yield and income out of agriculture is very poor. The mean annual rainfall is 1318 mm and mean maximum and minimum temperature is 35° and 18° C respectively.

Materials and methods

QuickBird satellite data of 2006 (Figure 1a,b), Leica GS 20 PDM global positioning system (GPS), Erdas Image processing software 9.1, Definiens Professional – 5 eCognition software were used.

In this study, both unsupervised and supervised clustering algorithm are examined. ERDAS Imagine was chosen to implement the ISODATA algorithm and the maximum likelihood technique for unsupervised and supervised classifications respectively. The object-based classification was tested with Definiens' software product, eCognition, which permits object-oriented, multi-scale image analysis.

Object-oriented classification

The process can be split into two steps, segmentation and classification.

Multi-scale segmentation

The object-oriented approach first involved the segmentation of image data into objects on the defined scale level. The subset images were segmented into object primitives or segments using eCognition. The segmentation of the images into object primitives is influenced by three parameters: scale, colour and form (Willhauck et al., 2000).

The scale parameter set by the operator is influenced by the heterogeneity of the pixels. The colour parameter balances the homogeneity of a segment's colour with the homogeneity of its shape. The form parameter is a balance between the smoothness of a segment's border and its compactness. The weighting of these parameters establishes the homogeneity criterion for the object primitives. A visual inspection of the objects resulting from variations in the weightings was used to determine the overall values for the parameter weighting at each scale level (table 1).

Table 1: Segmentation parameters for object oriented classification of forest and non-forest area

Classification	Scale level	Scale parameter	Shape factor	Compactness	Smoothness
Forest	1	10	0.1	0.5	0.5
Non-forest	1	5	0.1	0.5	0.5

Classification

Samples for each class were selected from the image objects to act as training areas for the classification. Objects were assigned class rules using spectral signatures, shape and contextual relationships. The rules were then used as a basis for the fuzzy classification of the data with the most probable/likely class being assigned to each object.

Pixel-based supervised classification

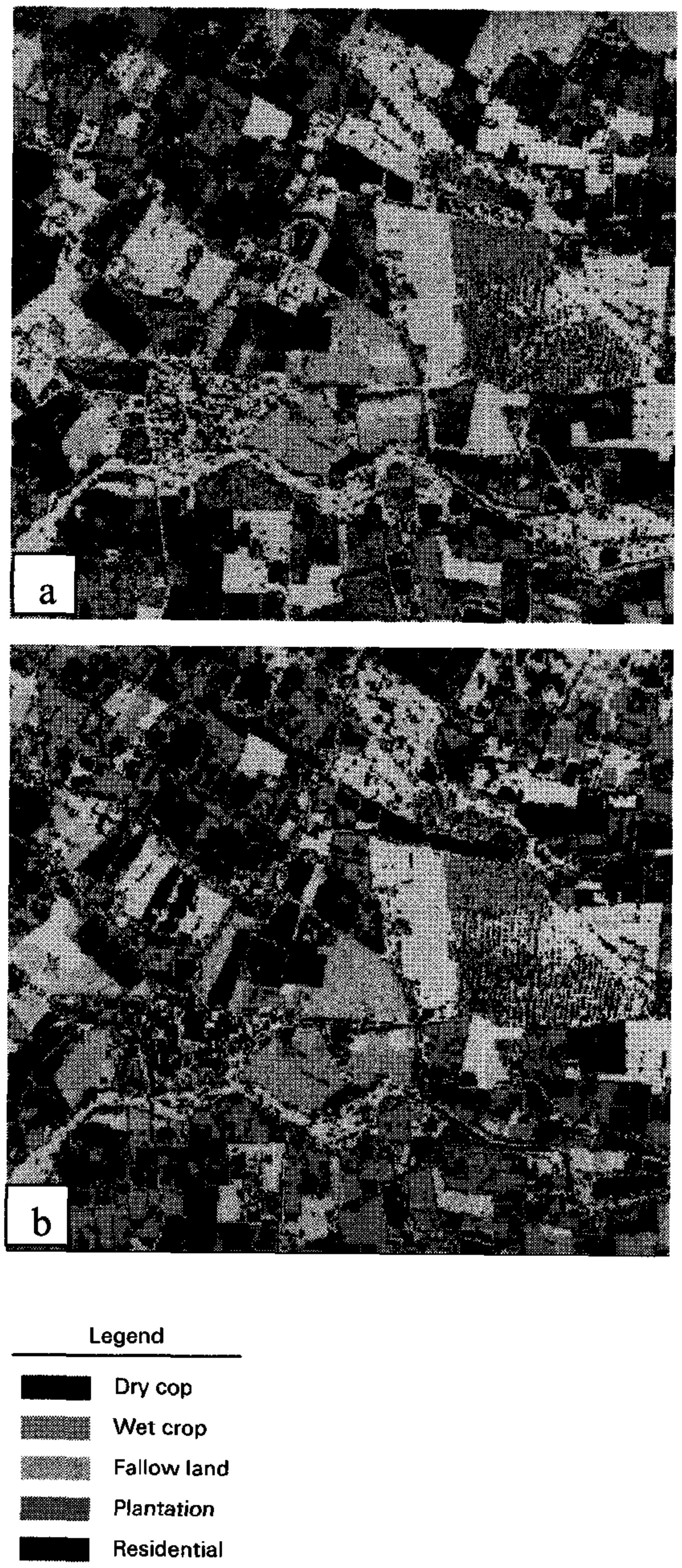
The pixel-based classification was undertaken using ERDAS Imagine v9.1 image processing software. It was a standard unsupervised and supervised classifications using the ISODATA and maximum likelihood algorithm [Jensen, 1996; Lillesand and Kiefer, 2000] respectively. The supervised classification method involved the selection of training areas representative of the 9 land cover classes totally in forest and non-forest areas. A number of training areas were selected to represent each class. The signature (or spectral mean) of the training area was then used to determine to which class the pixels were assigned.

Accuracy assessment

Accuracy assessments of both classifications were undertaken using confusion matrices and Kappa statistics (Congalton, 1991). The accuracy of the classified image was assessed using a range of reference data including field data collected in the study area. Producer and user accuracies for each class were calculated along with the overall accuracies and Kappa statistics (Congalton and Green, 1999).

Results:

The results of pixel based and object oriented classification show wide variation when it is observed visually (Figure 2a – d). The pixel based classification output shows many small groups of pixels or individual pixels, where as the object oriented classification shows multi-pixel features (Figure 2a – d). The unsupervised classification of forest and non-forest area produces a result which can not be used for anything. Therefore it is omitted in this study.



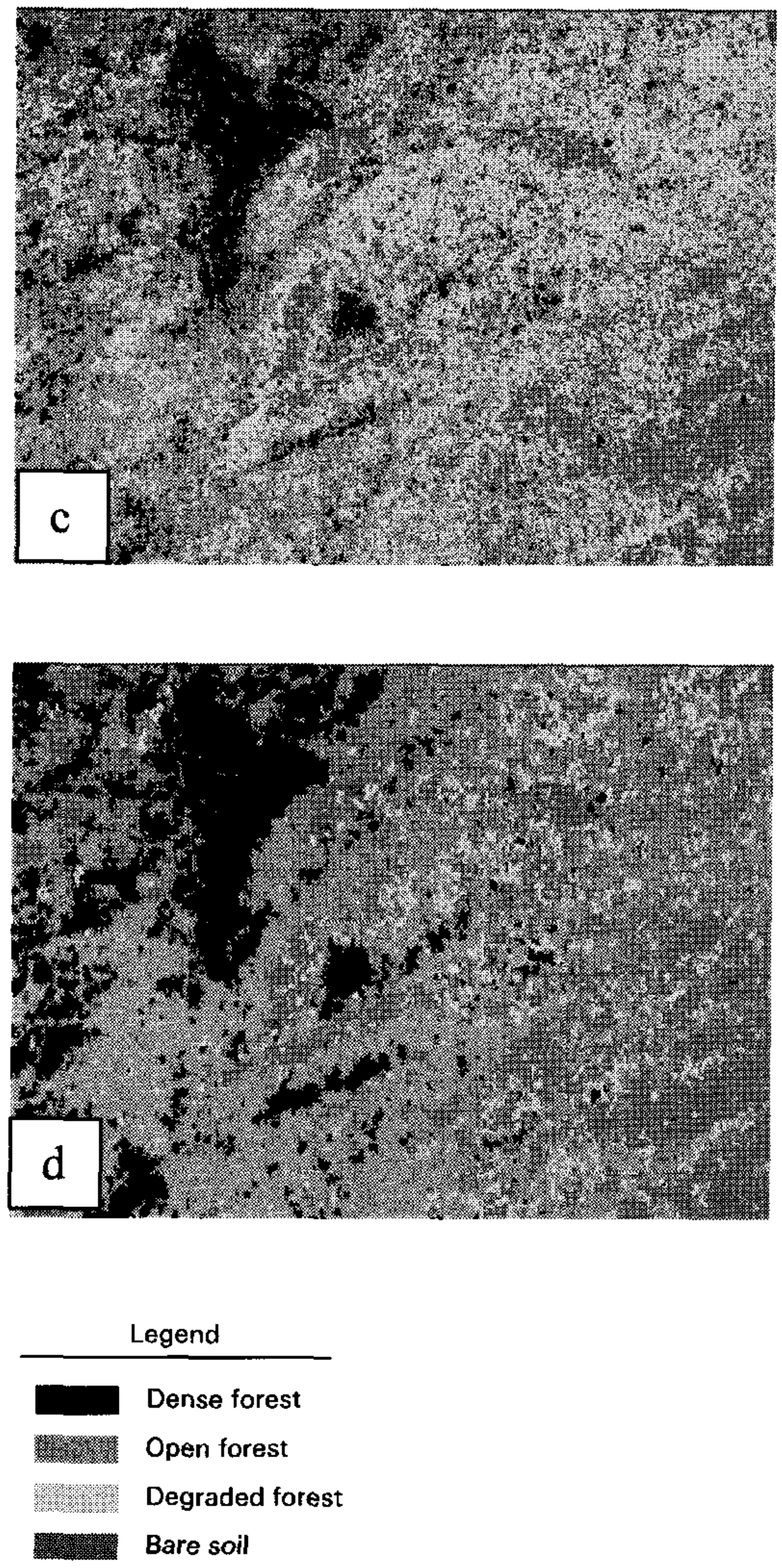


Figure 2. Classified images a) Pixel based classification of non-forest area, b) Object oriented classification of non-forest area, c) Pixel based classification of forest area, d) Object oriented classification of forest area.

Comparison of area

The total forest area is 120 ha and the total area of non forest area is 94 ha (Table 2 and 3). In the case of forest, except the barren soil class there are drastic differences in the area between pixel based and object oriented classification. In the case of non-forest area except fallow land all other classes show more variation in the area between these classifications.

Accuracy of Classification

It is to determine the agreement between the selected reference materials and the classified data. For this purpose, 125 pixel in the study have been selected randomly in both forest and non-forest areas and their agreement with ground truth has been analysed. Then, error matrix has been generated and given in table 2 and 3. This table includes the accuracies such as producer's, the user's and the kappa statistics.

In the case of forest the object oriented classification attains more weightages when compared to the pixel based classification. The user accuracy of dense forest and producer accuracy of degraded forest could be more or less related to the object oriented classification accuracies. In all the other classes the accuracy is always higher in the object oriented classification.

When comparing overall accuracy and Kappa statistics the object oriented classification attains 20% more value than the pixel based classification and in the Kappa statistics the object oriented classification is almost 100% better than the pixel based classification (Table 2).

In the case of non-forest area the classes such as residential and dry crop has similar producer accuracy between these two classifications. Wet crop, plantation and fallow lands have accuratdly classified in the object oriented classification than pixel based one. The overall accuracy also show more variation and the Kappa statistics is very high in the object oriented (0.6285) but it is very less in the pixel based classification (0.03834) (Table 3). The residential and plantation classes have been classified with low producer accuracy of 40 and 60 even in the object oriented classification. This may be due

Table 2. Area and accuracy statistics of pixel based and object oriented classification of forest area

Class name	Area in hectare		Accuracy of pixel based classification			Accuracy of object-oriented classification		
	Pixel based	Object – oriented	Producer (%)	User (%)	Kappa	Producer (%)	User (%)	Kappa
Dense Forest	10.35	20.93	58.33	70.00	0.6053	75.00	81.82	0.7608
Open forest	48.47	68.04	46.15	40.00	0.1892	78.57	64.71	0.5098
Degraded forest	38.88	9.26	47.06	57.14	0.3506	57.14	80.00	0.7222
Barren soil	22.83	21.79	75.00	54.55	0.4589	90.00	75.00	0.6875
			Overall accuracy = 54.00%			Overall accuracy = 74.00%		
			Overall Kappa = 0.03814			Overall Kappa = .0.6524%		

Table 3. Area and accuracy statistics of pixel based and object oriented classification of non-forest area

Class name	Area in hectare		Accuracy of pixel based classification			Accuracy of object-oriented classification		
	Pixel based	Object – oriented	Producer (%)	User (%)	Kappa	Producer (%)	User (%)	Kappa
Residential	2.61	7.66	40.00	40.00	0.3077	40.00	36.36	0.2657
Dry crop	37.22	23.69	72.22	61.90	0.4987	73.91	94.44	0.9199
Wet crop	3.64	6.07	66.67	60.00	0.5455	83.33	100.00	1.000
Plantation	18.07	22.79	27.27	20.00	0.0625	60.00	33.33	0.2308
Fallow land	32.77	34.15	48.15	68.00	0.5066	80.00	88.89	0.8485
			Overall accuracy = 52.00%			Overall accuracy = 70.67%		
			Overall Kappa = 0.03834			Overall Kappa = 0.6285%		

to the spectral similarity and irregular shape of these classes. The wet crop class has been classified with 100% user accuracy by the object oriented classification. All in all in this study the object oriented classification has produced better results when compared to the pixel based classification both in the forest and non-forest areas.

Conclusion

In this paper the Unsupervised, supervised and object classification methods have been tested on two different sites. The unsupervised classification has produced erroneous results therefore it has been omitted in this study for comparison. In the both the area the object oriented method using eCognition has produced better classification results with more producer, user and Kappa accuracy statistics.

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