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Research Article

Land Use Land Cover Mapping of West Garo Hills District of Meghalaya using Remote Sensing

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ABSTRACT

Remote sensing technology is the powerful tool for mapping because of its wide area coverage, gives information about inaccessible area, timely repetitive coverage of the same area. However, the image analysis is a challenging task. Digital classification is not always efficient, particularly if there are extreme variations in land cover as it exists in north eastern part of the country. In this study, classical technique of visual interpretation along with image enhancement technique was adopted for classification. In addition to this, classification through unsupervised and supervised techniques has also been followed to compare the relative accuracies. The result shows that classical technique of visual interpretation is a better way to classify the land use/land cover particularly for the hilly region where the algorithm based classification fails due to the very undulating topographical condition and complex spectral signature of vegetation.

Key words: Land use/land cover, Classification, Visual interpretation, Remote sensing

Introduction

In recent past, multi-spectral classification algorithms have been used to classify the satellite image. However, this classification method has a few disadvantages. It reduces the information content and may introduce misleading errors. The classification accuracy for each class degrades if number of classes increase. Moreover, variations in land cover like low to steep hills, shallow to deep valleys and undulating topography, misclassification errors might also creep up. Classifying a complex landscape from imagery has always been challenging to achieve a desirable accuracy (Manandhar *et al*., 2009).

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Keeping in view of the respective advantages and limitations, we analyzed for the best performance among the cluster based classification of unsupervised method with ISODATA clustering, per-pixel based classification of supervised classification with maximum likelihood, and digital visual interpretation based classification for land use/ land cover mapping.

Materials and Methods

Study area

West Garo district of Meghalaya is located in western part of the state between 90^{o} 30’ and 89^{o} 40’ E latitudes, and 26^{o} 00’ and 25^{o} 20’ N longitudes (Fig. 1), with geographic area of 3714

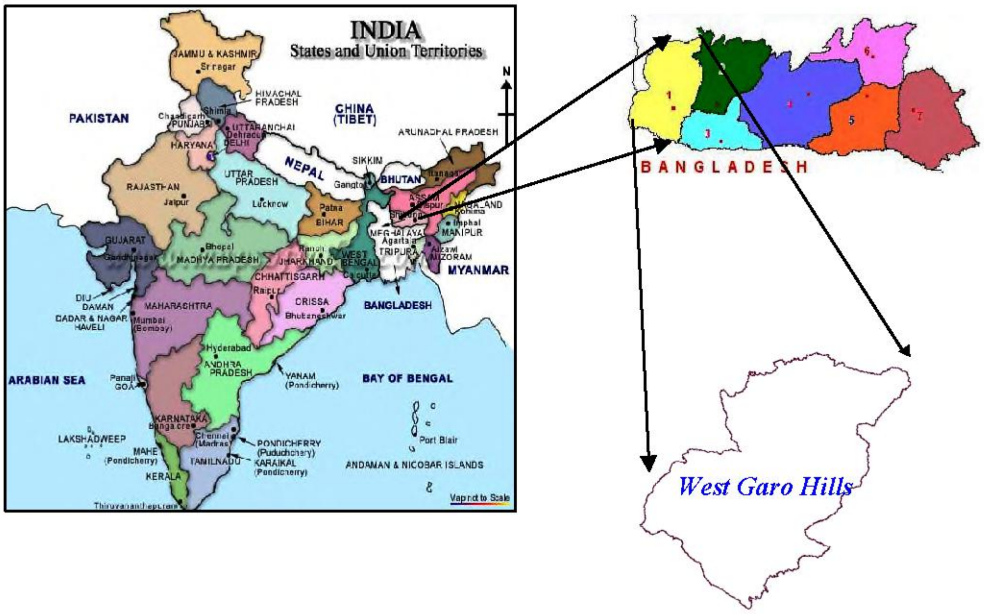

Fig. 1. Location map of the study area

km^2. The topography is mostly hilly with plains fringing the northern, western and the southern-western borders and covered under Tura, Arbella and Ranggira mountain ranges. The vegetation can be broadly classified into the flora of tropical, sub-tropical zones based on altitude. Agriculture pattern is mostly multi-cropping cultivation; Jhum cultivation is also practised. The climate is largely controlled by south-west monsoon and seasonal winds with average rainfall of 330 cm.

Image registration

The IRS P6 satellite image of the study area was registered with the help of Survey of India toposheets, and the corrected image was orthorectifited with the help of Landsat TM image. The ground control points were selected spatially along the scene and the RMS error was <0.7 pixles. Nearest neighbour method was used for image resampling.

Supervised classification

The image classification procedure automatically categories the pixels according to the statistical properties of the data or spectral signatures (Fig. 2). Based on independent information from the spectral reflectance of features in the image, it creates training sets depending upon the number of class to be classified. Classification algorithm was performed for selected land use/land cover type using the maximum likelihood classifier decision rule.

Unsupervised classification

Here the classification algorithm is based on clustering of pixel by using iterative self-organizing data analysis technique (ISODATA) (Fig. 3). The experts used to specify large number of groups or classes for each land use/land cover type, along with specific parameter related to the separation distance among the clusters. Once the clustering process is over, classes were combined into desired land use/cover types. Unlike supervised classification, unsupervised classification does not require analyst-specified training data. Values within a given land use type should have similar gray levels, but data in different classes should be well separated (*i.e.*, have very different gray levels) (Eastman, 1995; Lillesand and Kiefer, 2000).

Digital visual interpretation based classification

In reality, some features have very close spectral reflectance values and is therefore, very difficult to classify by normal algorithm based

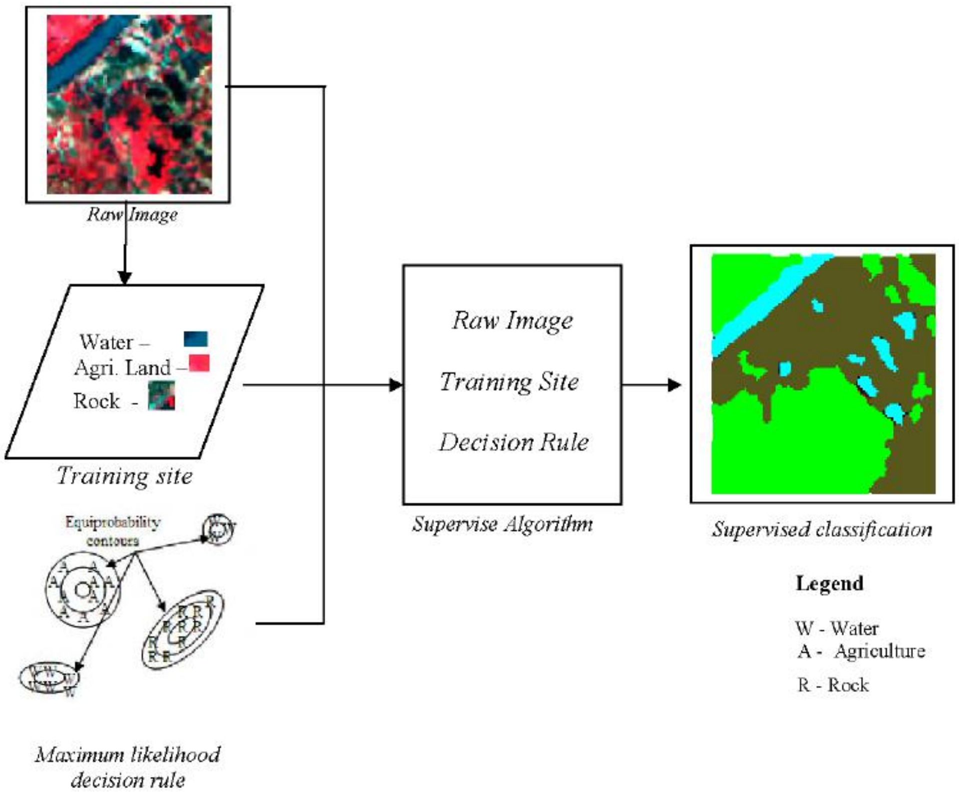

Fig. 2. Steps for supervised classification

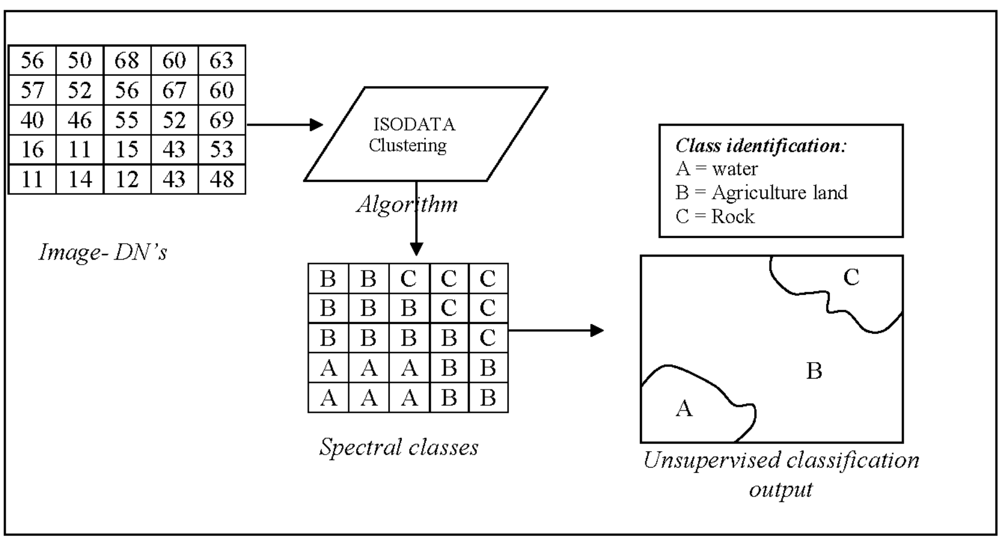

Fig. 3. Steps for unsupervised classification

classification (Fig. 4). To overcome this, digital visual interpretation based classification was performed. This involves visual elimination of objects and creating the land use/land cover types by manual onscreen digitations. It was performed by detection of objects using the visual elements (tone, shape, texture, pattern and association) and thereafter, interpretation based on different enhancement techniques (thresholding, data scaling, brightness adjustment, stretching, level slice, density slicing etc.). These are briefly discussed below.

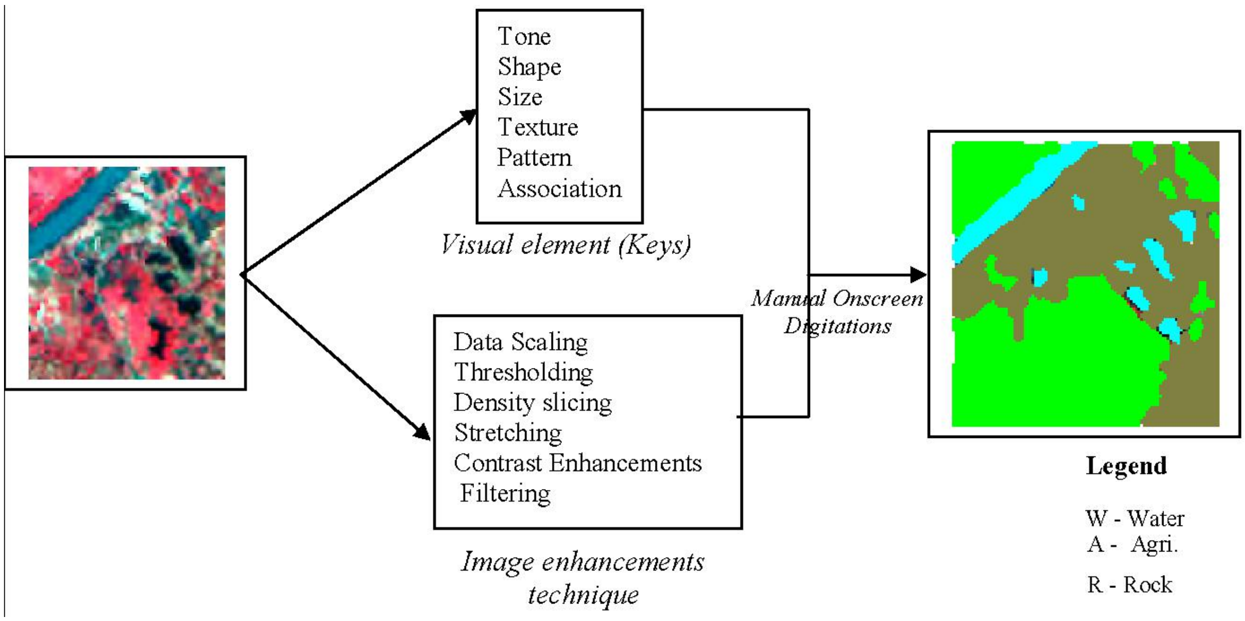

Fig. 4. Steps for digital visual interpretation based classification

The primary visual element is tone, which refers to relative brightness or colour of objects in the image. Different tonal effects on each object are shown in Fig. 5a *e.g.*, bluish tone represents the settlement, reddish for vegetation, greenish for grassland and light brown tone for barren land etc. The curvilinear shape in Fig. 5b in bluish tone represents the river, the irregular topography in the figure due to terrain area. Rough texture in an image consist of a mottled tone where the grey level of each band changes abruptly in a small area *e.g.*, forest canopy shows the rough texture among the forest area (Fig. 5c). Smooth texture would have very little tonal variation, like agricultural and barren lands. Similarly, the settlements area (Fig. 5a) shows continuous dotted squares of bluish tone with coarse texture (pattern). The scattered wetlands with bluish black tone are seen near the joining of tributaries in the main stream (association; Fig. 5d).

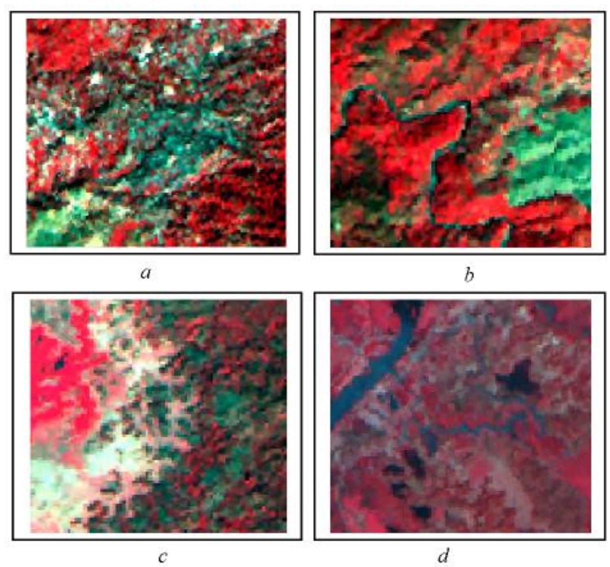

Fig. 5. Visual elements keys

During image enhancement, we examined the frequency distribution of the brightness values and applied threshold value of 40 to separate water body area from land. The reservoir, streams, river and man-made water barrier falls in water body categories. Through density slicing, the vegetated areas with brightness values ranging from 40 to 180 were grouped into single value of 75. Similarly, bare ground or paved surfaces with brightness values > 190 were grouped into a single value of 200. The image was also stretched (histogram stretch) to the useful brightness value ranges from 0-255 which will have much greater visual contrast and easier to interpret. The brightness inversion enhancement technique was also followed during image analysis. The accuracies of the classification were assessed by

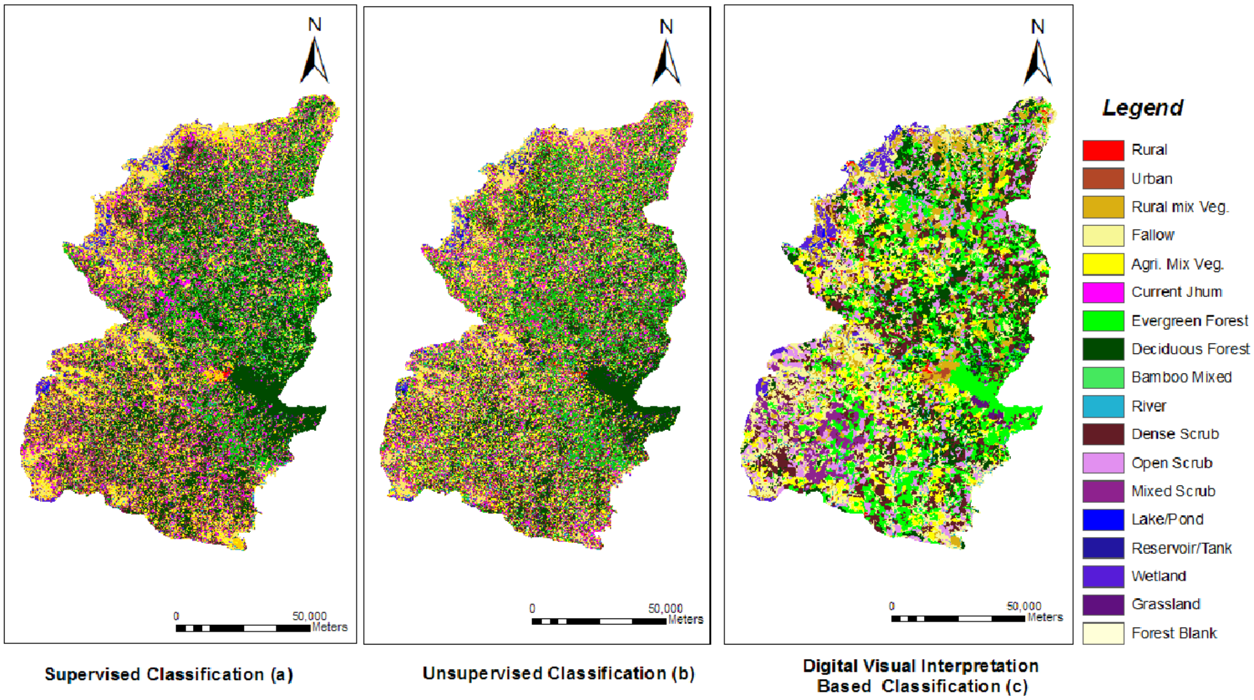

Fig. 6. Classified images using supervised, unsupervised and digital visual interpretation techniques

creating the error matrix using the same test area as reference data.

Results and Discussion

All together eighteen land use/land cover types were identified (Fig. 6a). Table 1 provides the information about the area obtained by each land type. The accuracy assessment for the supervised classified image shows the overall accuracy as 73.33%. In unsupervised classification, whole image was classified based on ISODATA clustering algorithm with 80 clusters of classes iterated to 20 times. Finally 18 land use/land cover types were identified (Fig. 6b) and their respective areas were generated (Table 1). The overall accuracy was 52.78%.

In digital visual image interpretation based classification technique, the study area was also classified into 18 classes. The land use/land cover types along with their area are given in Table 1 and the classified image is shown in Fig. 6c. The accuracy assessment for digital visual interpretation based classification reveals accuracy as high as 92.78%.

Comparison of the result based on accuracy assessment shows that digital visual interpretation based classification attains higher overall accuracy and higher individual land use/land cover accuracy as perceived. Highest accuracy through visual image interpretation was also reported by others (Ghorbani and Pakravan, 2013). The kappa statistics for three classification methods shows low kappa values for all the classes in unsupervised classification compared to supervised and digital visual interpretation (Table 2). However, when supervised and digital visual interpretation classification techniques were compared, classes like 'rural vegetation', 'reservoir/tank', 'river/streams', 'lake/pond', 'jhum', 'dense scrub', 'mixed scrub' and 'bamboo' shows higher accuracy through digital visual interpretation based approach.

Among the three techniques employed, digital visual interpretation based image analysis was not run by any algorithm. Each individual class was extracted from the image using visual element keys along with different enhancement technique which might have reduced miss-pixel classification due to spectral signature. The

Table 1. Area under different land types obtained by using three classification methods

Class Name	Area (ha)		
	Supervised	Unsupervised	Digital visual interpretation
Urban settlement	216.98	194.63	393.64
Rural settlement	3599.08	5259.46	1852.76
Rural mix vegetation	18009.74	8793.74	27425.68
Fallow	27930.76	31900.49	61858.97
Agriculture mix vegetation	37519.55	45462.07	27194.72
Current jhum	25833.98	27859.28	11229.99
Evergreen/semi-evergreen	93877.12	50727.34	76596.53
Deciduous forest	34595.68	55202.92	44704.69
Bamboo mixed forest	15493.91	21307.05	10347.60
River/stream	3757.08	6034.41	4105.19
Dense scrub	21789.56	35186.28	25867.85
Mixed scrub	6431.96	12735.88	9761.29
Open scrub	52045.52	31407.84	38074.31
Lake/pond	449.92	475.89	290.41
Reservoir/tank	13.48	18.61	2.16
Natural wetland	7583.28	7226.33	7154.01
Grassland	908.64	5977.15	2799.66
Forest blank	35.68	4321.67	25.76
Total area	350091.92	350091.04	349685.22

Table 2. The *kappa* statistics for unsupervised, supervised and visual interpretation classification techniques

Class Name	Supervised classification (%)	Unsupervised classification (%)	Visual classification (%)
Urban settlement	0.89	0.48	0.82
Rural settlement	0.68	0.57	0.91
Rural mixed vegetation	0.68	0.15	0.91
Fallow	0.86	0.57	0.94
Agriculture mix vegetation	0.89	0.6210	0.90
Current Jhum	0.58	-0.04	0.98
Evergreen/semi-evergreen	0.78	0.57	0.98
Deciduous forest	0.93	0.88	0.82
Bamboo mixed forest	0.46	0.82	0.86
River/stream	0.47	0.16	0.93
Dense scrub	0.37	0.56	0.76
Mixed scrub	0.47	0.56	0.89
Open scrub	0.68	0.47	0.91
Lake/pond	0.78	0.48	0.91
Reservoir/tank	0.58	0.28	0.96
Natural wetland	0.89	0.35	0.94
Grassland	0.89	0.78	0.92
Forest blank	0.79	0.19	0.90
Over all accuracy	0.72	0.50	0.92

unsupervised classification used ISODATA clustering algorithm and shows poor performance in classifying among each class due the complicated spectral signature in the study area. In supervised method, maximum likelihood decision rule algorithm was applied. The spectral value of a pixel was to be classified by the mean vector and covariance matrix. Unfortunately, some of the pixels values of some class-means were overlapped by the mean of the selected training site which leads to miss-classifications.

Conclusions

Overall, digital visual interpretation emerges as the best method for classifying an image. Our study area was a typical north-Indian district which has a complex land use/cover system. Digital visual interpretation did not involve any algorithm run analysis, and hence its performance was superior as compared to the supervised and unsupervised classification methods.

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