A Study on Pasture Land Degradation in Mongolia using RS

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Abstract: In this research, a study on the pasture land degradation in Arkhangai aimag, Central Mongolia is conducted. For the study, multitemporal RS images are used. To define the land degradation classes, initially, the RS images are classified using supervised (Mahalanobis distance) and unsupervised (isodata) classification methods. In order to accurately define the locations of the degraded sites, a field survey using Sony Pyxis GPS was conduced. The analysis was carried out using Erdas Imagine 8.6 installed in a PC environment.
Keywords: Pasture land degradation, supervised and unsupervised, classification.

1. Introduction

Pasture lands play an important role for the Mongolian animal husbandry, because they are grazing home to over 25 million head of livestock and are used by 192,000 herding families. Mongolian livestock producers still contribute a lot to the national economy. For example, in 2000 agriculture dominated by the livestock sector accounted for over a third of GDP, while livestock products such as cashmere accounted for 31.5 percent of the recorded value of the country's exports [8].

However, in recent years the Mongolian pasture lands have been seriously deteriorated and there have been different natural and socio-economic reasons on this. The severe droughts for the last few years and the growing number of livestock have been the main factors for the increasing land degradation in many parts of the country. Also the new herders who flooded to rural areas in search of livelihoods unavailable in the cities were inexperienced and in many cases they were ignorant of the customary rules of the traditional pasture use. The traditional system of grazing rotation between four seasonal pastures, followed by all experienced herders, has been increasingly ignored by the new herders. Out of season grazing for example, winter reserve pastures grazed by trespassers in summer, while the habitual user is absent had become common. At present, the pasture land degradation is a serious problem in Mongolia [5,6,8].

In this research, we conducted a study on the pasture land degradation in Jargalant, Erdene-Mandal and Tsetserleg sums of the Arkhangai aimag, Central Mongolia using multitemporal RS images. To define the land degradation classes, initially, the RS images have been classified using supervised (Mahalanobis distance) and unsupervised (isodata) classification methods. The results indicated that the supervised method performed more accurate than the unsupervised method. To verify the results of the RS image analysis, a field survey was conducted from 15 June to 3 July 2004. The analysis was carried out using Erdas Imagine 8.6 installed in a PC environment.

2. Data sources

- Landsat TM data of 9 September 1987
- Landsat ETM+ data of 28 September 2001
- Topographic maps 1:100,000
- Pasture map, 1:200,000
- GPS measurements
- Ground validation data.

3. Test site and land degradation in the study area

The test site covers Jargalant, Erdene-Mandal and Tsetserleg sums of Arkhangai aimag, Central Mongolia. By the forest-vegetation classification, the test area is included in the Khangai region and is dominated by the mixed landscapes of forest and steppe. In the isolated rural sites of the study region, it was very difficult to find accurate ground truth information related to the distribution of the winter camps of herders. Therefore, in order to conduct the thorough pastureland degradation study, we had to accurately define the precise locations of the winter camps. For this purpose, a field survey using Sony Pyxis GPS was conducted. The Landsat TM image of the study area and the spots of the GPS measurements are shown in Fig.1.

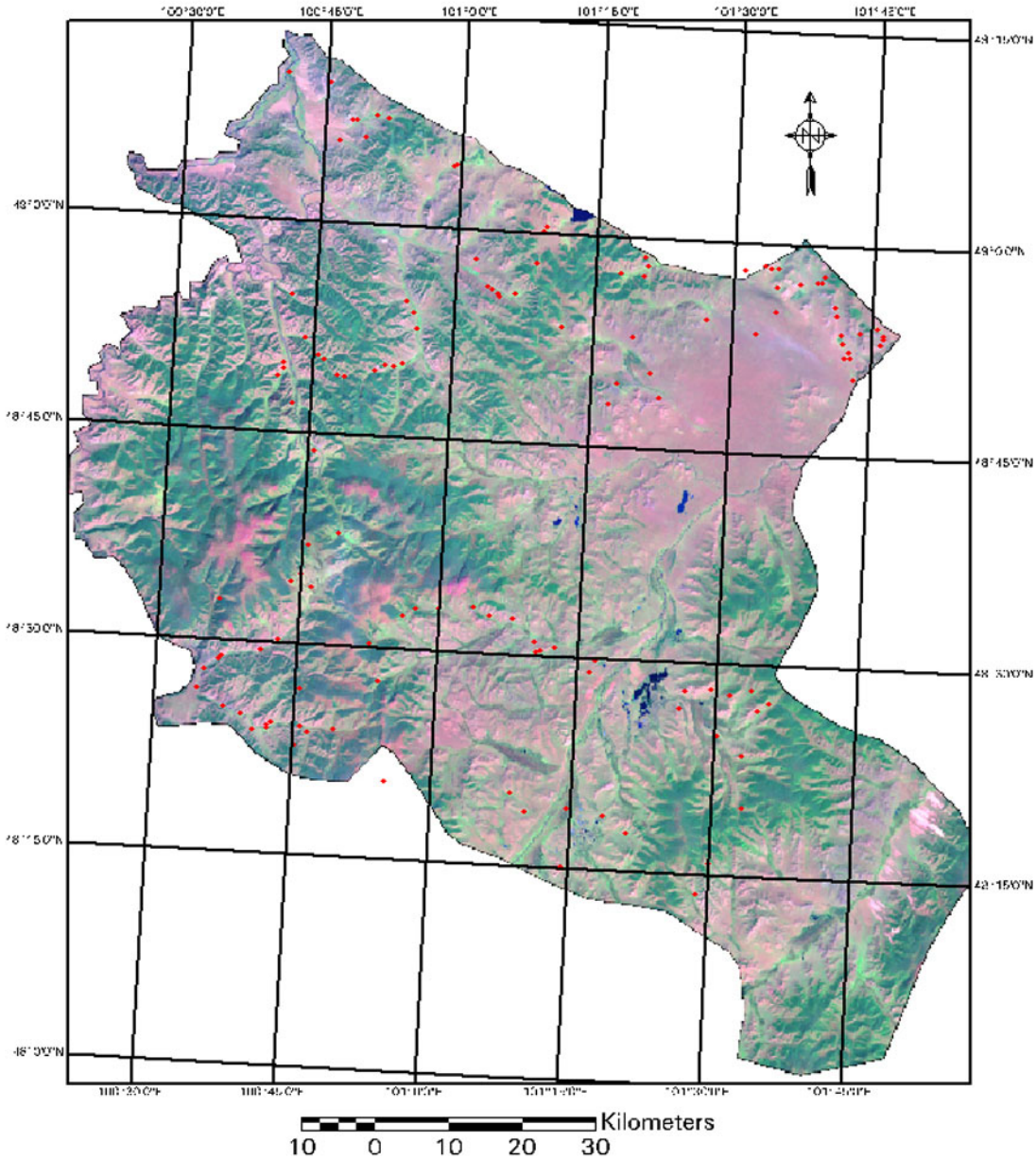

Fig.1. Landsat TM image of Jargalant, Erdene-Mandal and Tsetserleg sums of Arkhangai aimag and the spots of the GPS measurements.

As seen from Fig.1, the winter camps are located too close to each other (i.e. they are within 8km-10km distance from each other) and mainly built up appoaching the forest sides. The reason for that is because over the past few years there have been severe droughts in the region due to which some rivers and small lakes have been dried out. Moreover, because of the droughts the vegetation covers have been degraded. As a result, in summer herding families had to move to their camps only in June or July. Meanwhile, during autumn period the hay making has been

significantly reduced. Therefore, during both summer and winter seasons many herding families had to live together or closely live in good pasture areas, thus significantly degrading the pasture areas. Furthermore, due to heavy snow falls occurred in recent years, many herders lost some of their livestock and it created the imbalance among the livestock herd in this region. For example, now in the selected part of the aimag the cattle and big animals are 3-5%, sheep are 30% and goats are 65% of the total livestock [5,6].

4. Analysis and Discussion

Initially, in order to get the right georeference, Landsat TM and ETM+ images have been geometrically corrected to a Gauss-Kruger map projection using a topographic map of the test area, scale 1:100,000. For this purpose, linear transformation and nearest neighbour resampling approach have been applied and the related RMS errors were 0.82pixel and 0.78pixel for the TM and ETM+ images, respectively.

Then, the images have been classified using supervised and unsupervised classification methods. As the supervised method, Mahalanobis distance classifier, while as the unsupervised method Isodata clustering algorithm were applied. For both classifications, TM and ETM+ bands 3, 4, 5 and 7 were used.

The Mahalanobis distance classifier (MDC) is a parametric method, in which the criterion to determine the class membership of a pixel is the minimum Mahalanobis distance between the pixel and the class centre [1]. The Mahalanobis distance (MD_k) is expressed as follows:

$$MD_k=(x_i- m_k)^t V_k^{-1}(x_i- m_k) \qquad (1)$$

where x_i is the vector representing the pixel, m_k is the sample mean vector for class k, and V_k^{-1} is the sample variance-covariance matrix of the given class. The sample mean vectors and variance-covariance matrices for each class are estimated from the selected training signatures. Then, every pixel in the dataset is evaluated using the minimum Mahalanobis distance and the class label of the closest centroid is assigned to the pixel. To apply this method, initially, from the images, 2-3 areas of interest (AOI) representing the selected four classes have been selected. Then, training samples were selected on the basis of these AOIs. The separabilities of the training signatures were firstly checked on the feature space images and then evaluated using Jeffries-Matusita (JM) distance [2,3]. Then, the samples which demonstrated the greatest separabilities were chosen to form the final signatures.

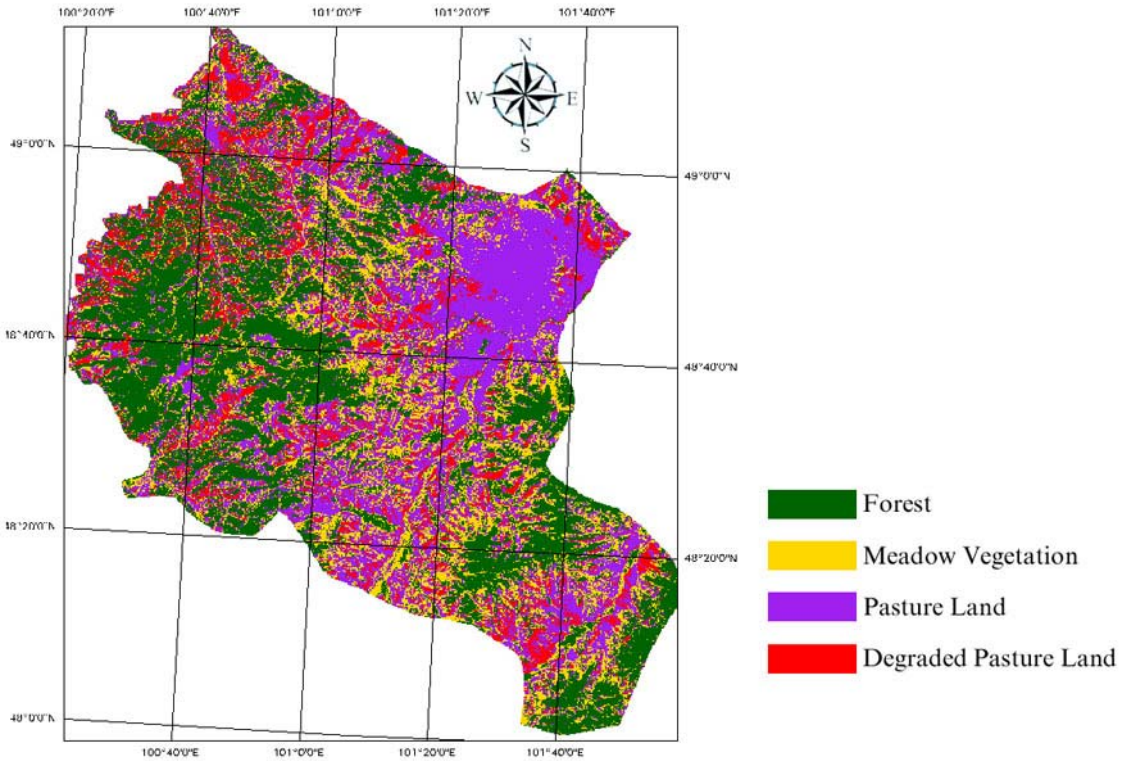

Fig.2. The classified image of Landsat TM data of 1987.

In the Isodata clustering, the following parameters have to be specified: N-maximum number of clusters, T-convergence threshold, M-number of iterations. On the basis of the first iteration the means of N clusters are calculated. After each iteration, a new mean for each cluster is calculated. These new means are used for defining clusters in the next iteration. The process continues until there is little change between iterations [2,7]. In our study, for the clustering the following parameters were assigned:

TM (N=12, T=95, M=24)

As a result of the iteration, initially 12 clusters have been defined. Then, the cluster separabilities were checked using JM distance. On the basis of the JM distance, the clusters have been merged and finally 4 clusters related to the selected classes were defined.

For the accuracy assessment of the classification results, the overall performance has been used. This approach creates a confusion matrix in which the selected reference pixels are compared with the classes in the classified image and as a result, an accuracy report is generated indicating the percentages of the correspondence [2,4]. In this study, as ground truth information, for each class different AOIs containing the purest pixels have been selected. The confusion matrices produced for the supervised method indicated overall accuracies of 88.09% and 89.91% for the TM-1987 and ETM-2001 images, respectively, whereas the confusion matrices produced for the unsupervised method demonstrated overall accuracies of 79.82% and 80.64% for the TM-1987 and ETM-2001 images, accordingly. The results of the supervised classifications for the TM-1987 and ETM-2001 images are illustrated in Fig. 2 and Fig. 3.

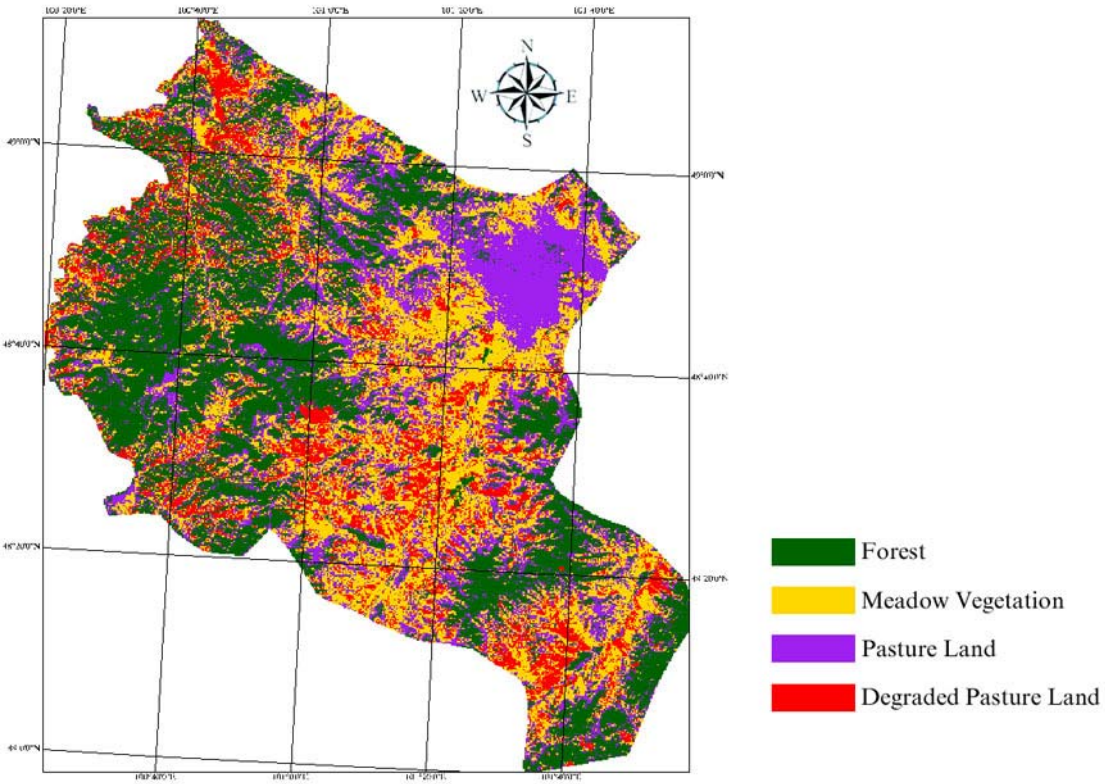

Fig.3. The classified image of Landsat ETM+ data of 2001.

After the classifications, the total areas belonging to the selected classes have been calculated and the areas related to each class presented in hectares (ha) are shown in Table 1. As seen from table 1, in 1987 forest and meadow vegetation occupied 308,168ha and 173,903ha, while by 2001 they had been reduced to 298,421ha and 207,692ha, respectively. Furthermore, as seen from table 1, in 1987 the pastureland and degraded pastureland occupied 276,084ha and 116,883ha, respectively whereas in 2001 they accounted for 252.772ha and 117,533ha, accordingly. Here, the forest reduction is directly related with illegal timber preparation of the local people, while the degradation of the meadow vegetation and pasturelands are related with overgrazing and other environmental factors.

Table 1. The total areas belonging to the selected classes.

	1987	2001
Forest	308.168	298.421
Meadow Vegetation	173.903	207.692
Pasture land	276.084	252.772
Degraded pasture land	116.883	117.533

As seen, multitemporal RS images with fixed time frequencies followed by the classifications can be successfully used for the pasture degradation studies.

Conclusions

The aim of this research was to study the pasture land degradation in Jargalant, Erdene-Mandal and Tsetserleg sums of the Arkhangai aimag, Central Mongolia using multitemporal RS images. To define the land degradation classes the RS images were classified using supervised and unsupervised methods. When the results of the classifications were compared, the supervised method performed better than the unsupervised method. In order to accurately define the precise locations of the winter camps, a field survey using SONY PYXIS GPS was conduced. Overall, the study indicated that the pastoral resources in the selected sums were significantly degraded and RS is a reliable tool for the pasture degradation studies.

References

[1] Amarsaikhan, D., Ganzorig, M., Adyasuren, Ts., and Saandar, M., 2002, The Principles of RS and GIS, pp.160, Ulaanbaatar, Mongolia.

[2] ERDAS, 1999, Field guide, Fifth Edition, ERDAS, Inc. Atlanta, Georgia.

[3] Ganzorig, M., and Amarsaikhan, D., 1997, Comparison of Different Pattern Recognition Techniques, Scientific Papers of Informatics Institute, MAS, pp.71-75.

[4] Mather, P.M., 1999, Computer Processing of Remotely-Sensed Images: An Introduction, Second Edition, (Wiley, John & Sons).

[5] National Statistic Information, 2004. Agricultural Sector, Department of National Statistic of Mongolia, Ulaanbaatar, pp.34-36.

[6] Newsletter of Mongolian Food and Agriculture, 2004, Ministry of Food and Agriculture, No:2, pp.16.

[7] Richards, J.A., 1993. Remote Sensing Digital Image Analysis-An Introduction, 2nd edition (Berlin: Springer-Verlag).

[8] Sustainable Grassland Management, 2000, Project Document, Project of the Government of Mongolia and UNDP, pp.48.