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RARE VEGETATION DEGRADATION IN RELATION TO CATTLE GRAZING IN GOBUSTAN, AZERBAIJAN: CLASSIFICATION AND CHANGE DETECTION FROM REMOTELY-SENSED IMAGES

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Abstract

This paper describes remote sensing methodologies for monitoring rare vegetation with special emphasis on the Image Statistic Analysis for set of training samples and rare vegetation classification. The different methods analysis such as signature statistics, signature and scatter plots are used. According to the results, the average Transformed Divergence is 1972, minimum is 1847 and maximum is 2000 which shows an acceptable level of accuracy. Study reveals that optical remote sensing techniques could effectively be used to assess rare vegetation and map them accordingly with a reliable accuracy of 91%. The classification results indicate that major changes in the study area from 2004 to 2012 years involved decrease in vegetation cover types including Alhagi pseudoalhagi (-0.7%), Salsola Nodulosa/Artemisia Lerchiana/Salsola Dendroides communities (-18.7 %) and Suaeda Dendroides (-5.24 %); and increase in Tamarix (+21.7 %) and Bare ground (+3.6 %).

Keywords: *Remote Sensing, Image statistical analysis , Classification*

Introduction

Traditionally, the main land use system of Azerbaijan used to be extensive livestock breeding with summer pastures in the mountains and winter pastures in the lowland steppes. Overgrazing of winter and summer pastures by domestic sheep, goats and cattle is a major threat to terrestrial Biodiversity. Grazing by cattle has affected large areas of natural grassland habitats, and has contributed to soil erosion. Overgrazing by cattle reduces the amounts of plant matter available to other natural herbivores in the environment, thus decreasing their numbers and changing the dynamics of the community. Overgrazing can also cause the local extinction of plants in some areas [1].
Some vegetation is strictly protected by law, while others extensively for livestock grazing, particularly in the winter when mugwort species (*Artemisia species*) are palatable to animals due to low concentrations of alkaloids. In the spring and summer alkaloid concentrations are high making the plants unpalatable. Saltwort species (*Salsola nodulosa*) is a plant of very high nutritional value and provides much more energy per gram than mugwort species [2].

Remote sensing is expected to provide us an efficient tool for monitoring vegetation environment.
It can be used when collecting background information about the pastures and can be further processed by the GIS. The information and results produced are usable for planning and management purposes of rare vegetation in the Study Area [3]. The SPOT 4 images used in this study was taken in April and August, at a time when the summer pastures were already heavily grazed. This was visible both in the field and in the satellite image.

Study Area

The Gobustan is located between the southern outcrops of the Caucasus Mountain range and the Caspian Sea, some 60 km south of the capital Baku as in presented in the Figure 1. The Gobustan semidesert extends on 1780 km² (178 700 hectares) and is characterized by a semi-arid climate with continental influence and humid, cool winters and dry hot summers. The mean July temperature reaches 26.4°C and the mean January temperature 2°C in this area. Average rainfall is 200-400mm per year in Azerbaijan but can be as little as 150-200mm in semi-desert areas such as Gobustan .

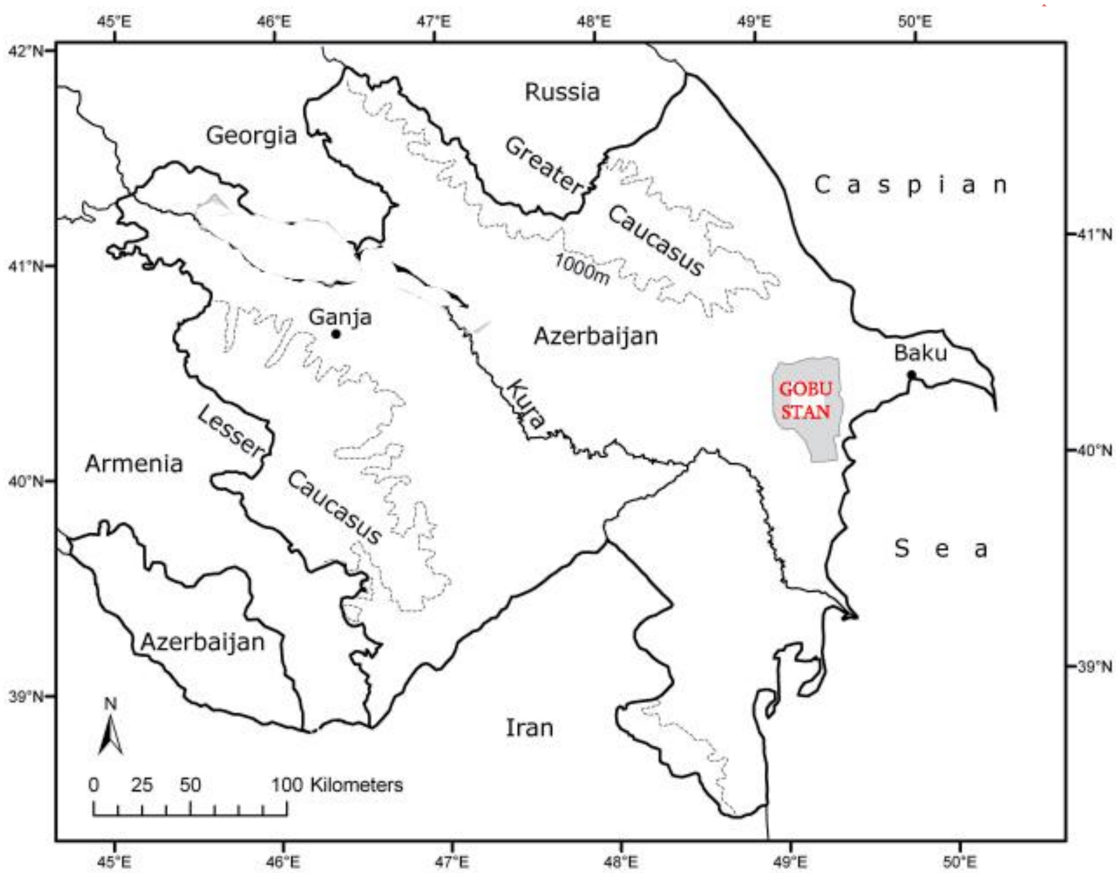


Figure 1: Study Area

Data Used and Methodology

The fundamental basis of this study is Remote sensing imageries which came from Spot Image in 2.5m, 5m and 10m resolutions. In combination with more recent data (SPOT4 satellite data from 2010 and 2012), these early images enable us to study how Study area has changed over time (Figure 2). Flow-chart in Figure 2 shows the analysis methods applied in the research to attain the research objectives.

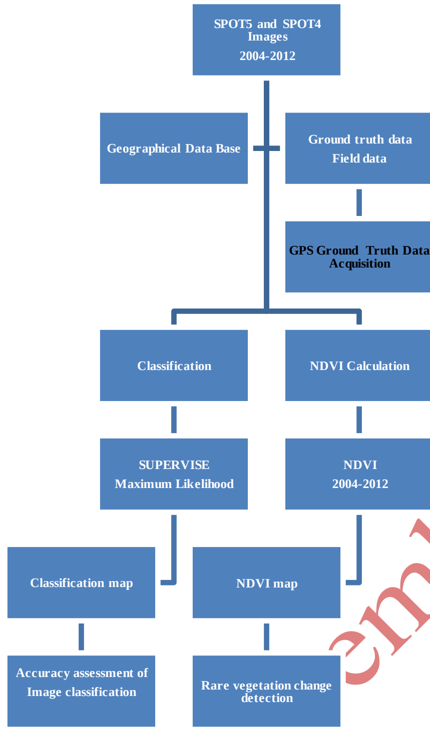


Figure 2: Flowchart of methods applied in the study

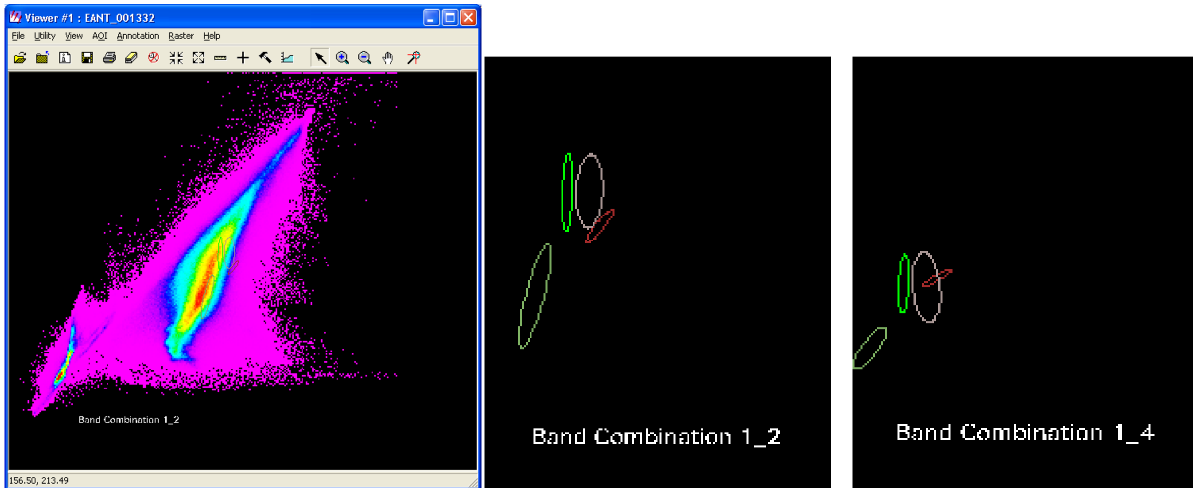
Image Statistical Analysis

The first stage in accuracy interpretation was to calculate the statistics for each class. By examining the distance between the means of the class's values it is possible to make preliminary estimations of the accuracy of the following classification.
Once the training areas are selected, different methods are used for testing purposes such as histograms, separability, signature statistics and scatter plots.

The visualization technique in feature space allows estimating range of the correlation of training samples: thereto, for each of the class from the training data was estimated of Minimum and Maximum values on each band used and created three-dimensional parallelepiped in the feature space. Or, another way is to define a three-dimensional ellipsoid, estimated of Mean ± Standard deviations values on each band used.

Compare Ellipses

We can view graphs of these statistics for compare classes. The graphs display as sets of ellipses in a Feature Space image. Each ellipse is based on the mean and standard deviation of one class. The color is used as the color for the class in the visualization functions, ellipses, *etc*. The ellipses are presented with the color regarding each class as is shown in table below.



Class #	>	Signature Name	Color	Red	Green	Blue
1	>	Alhagi-pseudoalhagi		0.480	0.670	0.376
2		Tamarix		0.000	1.000	0.000
3		Suaeda dendroides		0.647	0.165	0.165
4		SalNod/ArtLerch/SalDend		0.658	0.585	0.581

Figure 3: Band combination. Sets of ellipses in the Feature Space Image

By comparing the ellipses for different classes for a one band pair, it is easy to see if the training set represents similar groups of pixels by seeing where the ellipses overlap on the Feature Space image (Figure 3).

Class Separability

Separability is a statistical measure of distance between two classes. Separability can be calculated for any combination of bands that is used in the classification, enabling you to rule out any bands that are not useful in the results of the classification. These distances used to determine the best results to use in the classification. Some researchers sought to test whether some bands had more discriminating power than others by using the Jeffries-Matusita distance analysis technique only [4], [5]. Other researchers, for this purpose, Divergence Distance or Battacharrya Distance were used to measure the separability [6].

We evaluated Class Separability on the following formulas:

- Transformed Divergence
- Jeffries-Matusita distance

If the spectral distance between two samples is not significant for any pair of bands, then signatures may not be distinct enough to produce a successful classification. It was evaluated the Average and Minimum separability on all formulas for the band set.

It was calculated *Transformed Divergence (TD)* and *Jefferies-Matusita Distance (JM)* for every class pair and one band combination. Then we compared these numbers (values) to other separability listings for other band combinations to determine which set of bands is the most useful for classification.
The *Transformed Divergence* matrix and the *Jefferies-Matusita Distance* separability matrix on the best band combinations are presented in Table 1 and Table 2.

Table 1: Transformed Divergence separability matrix for training classes

Distance Measure: Transformed Divergence
Using Layers: 1 2 3 4
Taken 4 at a time
Best Average Separability: 1971.89
Combination: 1 2 3 4

Signature Name		1	2	3	4
Alhagi-pseudoalhagi	1	0	1986.45	2000	1998.31
Tamarix	2	1986.45	0	2000	1846.55
Suaeda dendroides	3	2000	2000	0	2000
SalNod/ArtLerch/SalDend	4	1998.31	1846.55	2000	0

Table 2: Jefferies-Matusita Distance separability matrix for training classes

Distance Measure: Jefferies-Matusita
Using Layers: 1 2 3 4
Taken 4 at a time
Best Average Separability: 1354.89
Combination: 1 2 3 4

Signature Name		1	2	3	4
Alhagi-pseudoalhagi	1	0	1343.8	1414.14	1378.17
Tamarix	2	1343.8	0	1409.3	1214.62
Suaeda dendroides	3	1414.14	1409.3	0	1369.34
SalNod/ArtLerch/SalDend	4	1378.17	1214.62	1369.34	0

Analyzing the numerical *TD* values (Table 2) we can conclude that the Separability results for training samples on the classification scheme are good.

The Best Average Separability is 1972, Minimum Separability is 1847. The results of the Best Minimum and Best Average Separability have been presented in the Table 3.

Table 3: Transformed Divergence separability matrix for training classes

Band Combination	**Transformed Divergence** MIN	AVE	**Jefferies-Matusita Distance** MIN	AVE
1	1210	1806	371	1806
1 3	1791	1965		
1 4			1049	1244
1 2 3	1824	1971		
1 3 4			1159	1321
1 2 3 4	1847	1972	1215	1355

Having acceptable levels for the separability of the training areas, the next step is to conduct the classification process. Overall, Class Separability is adequate and would provide an accurate classification.

A common method for classification accuracy assessment is through the use of the Contingency Matrix (Table 4). Contingency Matrix do a quick classification of the pixels in a set of training samples to see what percentage of the sample pixels are actually classified as expected .

Contingency Matrix do a quick classification of the pixels in a set of training samples to see what percentage of the sample pixels are actually classified as expected [7].

Accuracy assessment

Accuracy assessment is an important step in the classification process. The goal is to quantitatively determine how effectively pixels were grouped into the correct feature classes in the area under investigation. The confusion matrix is used to illustrate class agreement and error in greater detail by showing the relationship between the validation sites and the percentage of these pixels actually classified into the various classes by the maximum likelihood classifier [8], [9].

Table 4: Contingency Matrix

ERROR MATRIX

Classified Data	Reference Data: Alhagi-pse	Tamarix	Suaeda den	SalNod/Art
Alhagi-pse	86.67	5.41	0.00	0.00
Tamarix	13.33	94.59	0.00	8.57
Suaeda den	0.00	0.00	100.00	2.86
SalNod/Art	0.00	0.00	0.00	88.57

The Overall Accuracy is 91%

Results and Discussion

Supervised classification of remotely sensed data

Maximum Likelihood Classification algorithm was used in supervised classification. From the supervised classification (Figure 5) of SPOT data five classes can be well identified. Resolution of SPOT5 data is 2.5 m, 5 m and 10m.

The results indicates that major changes in the study area from 2004 to 2010 years involved decrease in vegetation cover types including *Alhagi pseudoalhagi* (-0.7%), *Salsola Nodulosa/Artemisia Lerchiana/Salsola Dendroides* communities (-18.7 %) and *Suaeda Dendroides* (-5.24 %); and increase in *Tamarix* (+21.7 %) and *Bare ground* (+3.6 %) (Table 5 and Figure 6).

Table 5: Rare vegetation degradation from 2004 to 2010 years

Rare vegetation communities	**Area in hectares, 26-09-2004**	**% of the area**	**Area in hectares, 01-08-2010**	**% of the area**	**% change between both periods**
Alhagi pseudoalhagi	470.0	23.5	444.1	22.8	0.7 decrease
Tamarix	268.0	13.6	533.7	35.3	21.7 increase
Suaeda Dendroides	264.0	13.4	17.4	1.2	12.2 decrease
Salsola Nodulosa/ Artemisia Lerchiana/ Salsola Dendroides	958.3	48.5	449.3	29.8	18.7 decrease
Bare ground	16.7	0.84	65.7	4.4	3.56 increase

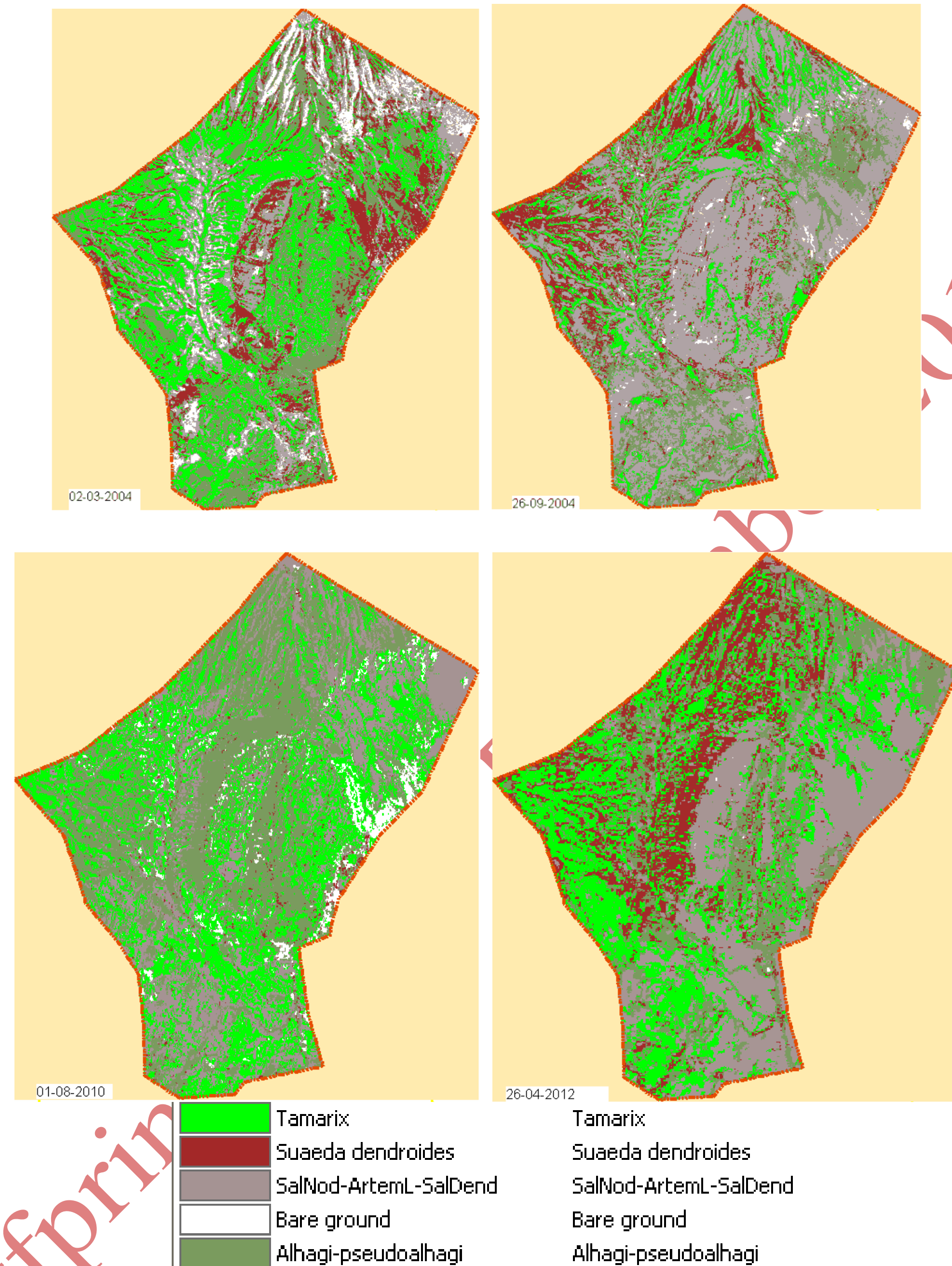


Figure 5: Rare vegetation classification from 2004 to 2012 years

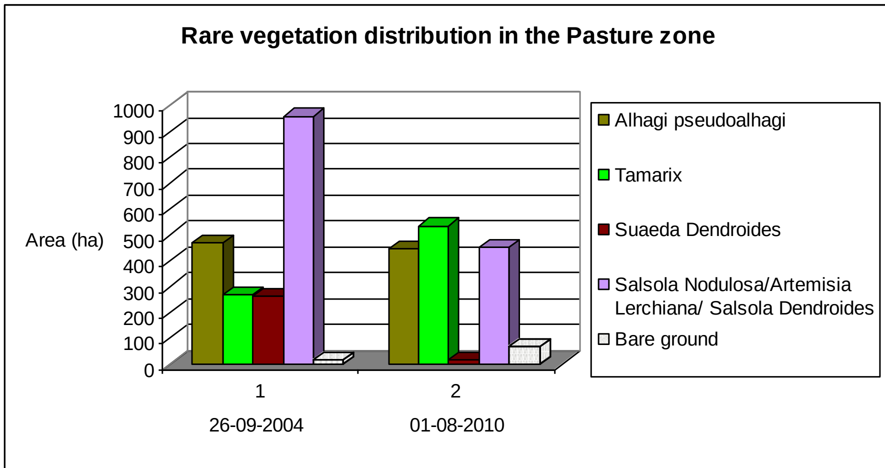


Figure 6. Rare vegetation distribution in the Pasture zone

Conclusion

The SPOT images is the remote sensing data in used this study. The aim of this study was to perform the Image Statistical analysis in the training stage and rare vegetation classification. The number of multivariate statistical techniques was employed to estimate the degree of discrimination between the classes. At every step of the training process, values of Class Separability as represented by Transformed Divergence and Jefferies-Matusita Distance where evaluated as a measure of the quality of training areas.
The image classification was done in the ERDAS Imagine program. The final map producing and the accuracy assessment were performed in the ArcGIS program. The SPOT images proved to be a useful data source in the mapping of pastures in the Gobustan area. The main vegetation classes were classified accurately.

Acknowledgement

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References

[1] Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas Submitted to the Secretariat of the Convention on Biological Diversity, (2000).

[2] ESIA Ecological Baseline Report, (2002).

[3] Gambarova, Y., Gambarov, A., Sefikhanly, V., Kerimly, U. and Aliyev, G. Monitoring pastures in Gobustan, Azerbaijan: Geographical Data Base design and creation of Specialized GIS Environment, *International Geoinformatics Research and Development Journal*, Vol. 4, Issue 3, (2013).

[4] Thomas, I., Benning, V. and Ching, N., Classification of Remotely Sensed Images, Adam Hilger, London, (1987).

[5] Dutra L., and Huber, R., Feature Extraction and Selection for ERS-1/2 in SAR Classification, *International Journal of Remote Sensing*, (20), 993- 1016, (1999).

[6] Mutanga, O., Riyad, I., Fethi, A. and Lalit, K., Imaging Spectroscopy (Hyperspectral Remote Sensing) in Southern Africa: An Overview, *South African Journal of Science*, (105), 83-96, (2009).

[7] Smits, P., Dellepiane, S.G. and Schowengerdt, R., Quality Assessment of Image Classification Algorithms for Land-Cover Mapping: A Review and a Proposal for a Cost-Based Approach, *International Journal of Remote Sensing*, (20), 1461-1486, (1999).

[8] Jensen, J.R. Introductory Digital Image Processing: A remote sensing perspective 3rd Prentice Hall New Jersey, (2005).

[9] Lillesand, T. and Kiefer, R., Remote sensing and image interpretation. (4th) New York: John Wiley & Sons, (2000).