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MONITORING PASTURES IN GOBUSTAN, AZERBAIJAN: GEOGRAPHICAL DATA BASE DESIGN AND CREATION OF SPECIALIZED GIS ENVIRONMENT

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Abstract

This paper describes GIS and RS methodologies for monitoring threats of rare vegetation with special emphasis on the monitoring pastures which is the main threat facing to rare vegetation and their habitats in the Gobustan State National Park, Azerbaijan. A Geographical Data Base of all the available spatial data for the Study area and Map of current pasture usage are created and can be used for future analysis and planning of research and conservation of rare vegetation. The main pasture types, Pure Pastures and Stony Pasture were distinguished. Satellite images of high resolution, land use maps, and maps of archaeological site, made by field observation are used. All Remote sensing data are verified through field check during field observation accomplished by special field observation method. A Specialized GIS Environment was created and used as software environment for performing workflow comprising of jobs connected with collecting samples, hosting classifier training and producing software as well as classification results analysis in the future.

Keywords: Remote sensing, GIS, Geographical Data Base, Specialized GIS Environment

INTRODUCTION

Overgrazing and uncontrolled livestock grazing threatens steppe and semi-deserts ecosystems in Azerbaijan. A third of pasturelands in the region are subject to erosion. Sheep grazing in the winter ranges and semi-deserts of Azerbaijan has nearly tripled in the past decade. Intensive grazing has resulted in reduced species diversity and habitat degradation. Overgrazing is causing environmental damage in much of the hotspot, particularly in the Gobustan National Park.

The semi-arid lowlands of Azerbaijan have been used as pastures since millennia [1]. And still today they provide very important fodder grounds for livestock production. Apart from the oil business, agriculture including livestock breeding plays the most important role in the country accounting 21.6% of the GDP in 1999. More than 40% of its area is used as rangelands and a third of the population is directly engaged in agriculture [2].

About 200 farmyards are distributed across the Gobustan area which is used as winter pasture, benefited by often snow-free winters. From October till May pastoralists with their livestock and families stay here, in the hot, dry summers no sheep and people live in the region. Dwarf shrubs supply winter fodder and ephemeral plants are used in early spring. Main sheep breed in Azerbaijan is the fat-rumped sheep (Ovis steatopyga) [3].

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 [4].

Remote Sensing (RS) and GIS is a suitable tool for pasture inventory in the Gobustan. 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 [5].

The SPOT 4 images proved to be a useful data source in the mapping of pastures in Gobustan. The SPOT 4 images used in this study was taken in May 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.

Remote sensing and GIS have been used in many studies in those areas where degradation and erosion are a problem. In some cases the cause of degradation has been supplemented by increased grazing and human impact [6], [7], [8] and [9].

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 [10].

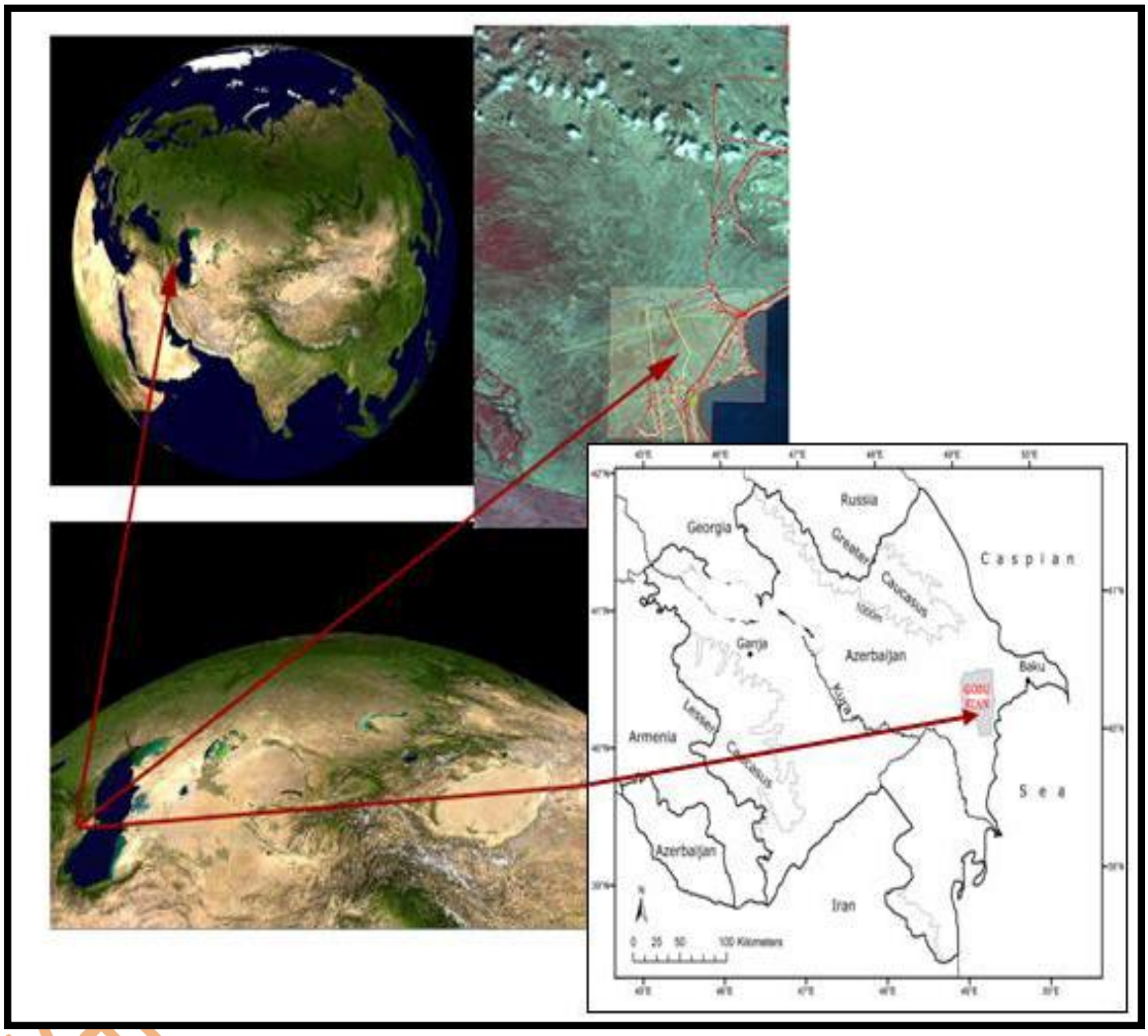

Figure 1. Study Area

DATA USED AND METHDOLOGY

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).

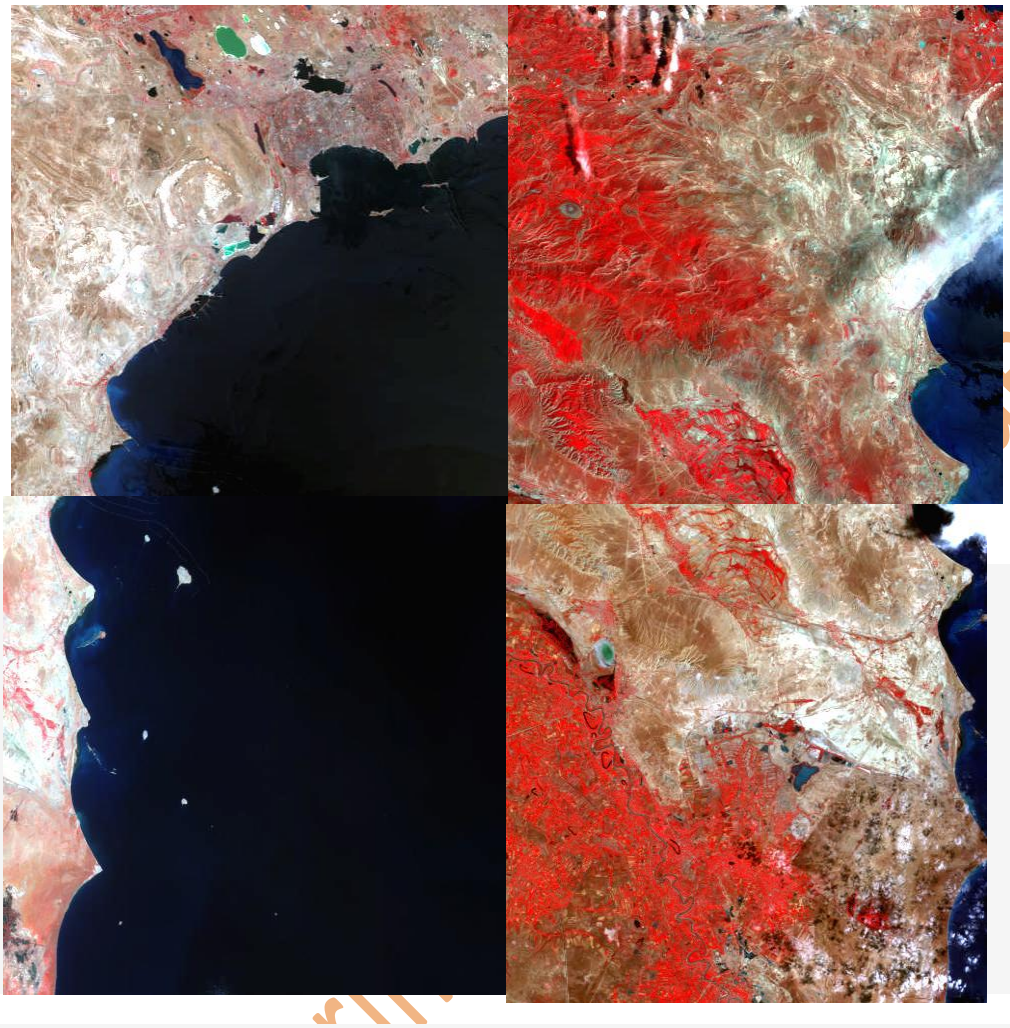

Figure 2: SPOT4 Images used in this study

The SPOT images proved to be a useful data source in the mapping of pastures of the Gobustan area (Figure 2).

The SPOT4 image used in this study was taken in May 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. We have created visual tools to guide and enhance conservation management initiatives in the Gobustan. These tools include a series of current Land Use and Topographical maps that aid vegetation managers (Figure 3).

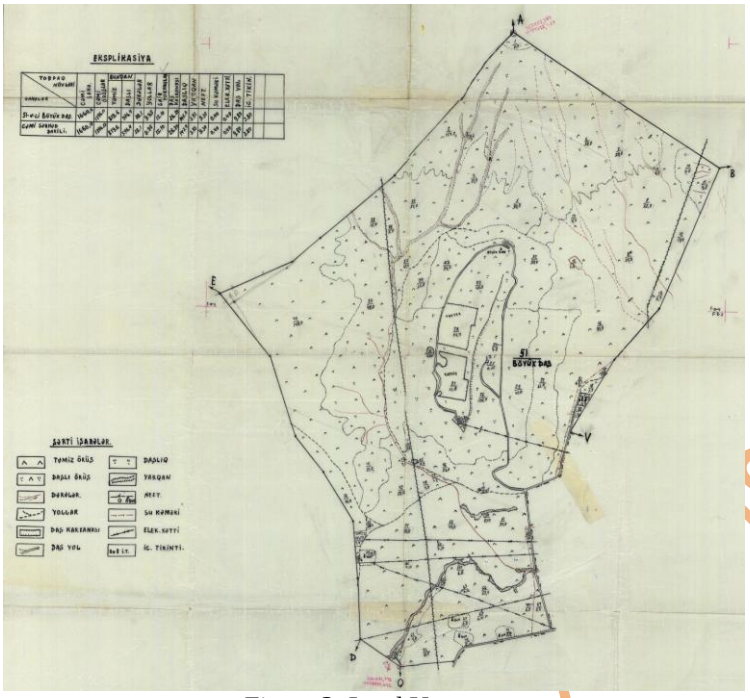

Figure 3: Land Use map

GROUND TRUTH SURVEY

Field data collection is important in remote sensing [11]. The field data serve three purposes. Firstly, field data can be used to verify, to evaluate or to assess the results of remote sensing investigations [12]. Secondly, field data can provide reliable data to guide the analytical process, such as creating training fields to support supervised classification.

The Field surveys were hold in accordance with preliminary data on the spreading of rare plants in the study area. Because GPS devices provided the coordinates for ground-reference data during fieldwork, the sample plots were accurately linked to SPOT imagery. Every plot was registered with GPS device to allow further integration with spatial data in GIS and image processing systems. Information on land use was recorded. Data from the field work was entered into a database. The field sampling method used was basically the same as the one used in paper [13].

IMAGE ANALYSIS

Geographical data base design, data automation and loading

In order to trace the dynamics of rare vegetation distribution over the period from 2007 to 2012, we have selected the part of the Gobustan area, where the vegetation was most sensitive to threats such as overgrazing, infrastructure, etc.
Raster data is commonly obtained by scanning maps. Georeferencing is used to create GIS databases. It is the process of assigning a geographic location (e.g. latitude and longitude) to a geographic feature on the basis of its address. For georeferencing it needs to establish control points, input the known geographic coordinates of these control points and choose the coordinate system and other projection parameter:
Projected Coordinate System: WGS_1984_UTM_Zone_39N
Projection: Transverse_Mercator

Using ArcGIS software, we created updated Geographical Data Base consisting of relevant spatial data. District boundary maps, survey maps and SPOT4 satellite images, vector polygons such as geographical areas of historic site were graphical components of GIS Design and Application (Figure 4).

The Generated Land Use Map with the following layers:

- Pastures
  - Pure Pastures
  - Stony Pastures
- Lowland
- Roads
- Railroad
- Settlement
- Oil pipeline
- Gas pipeline

etc. has been using for realization of workflows such as:

- Optimization of site distribution for extraction training and test sets;
- Determination of optimal spur-track (diversion route) to object of interest;
- Organization of data post-processing and verification of classification results.

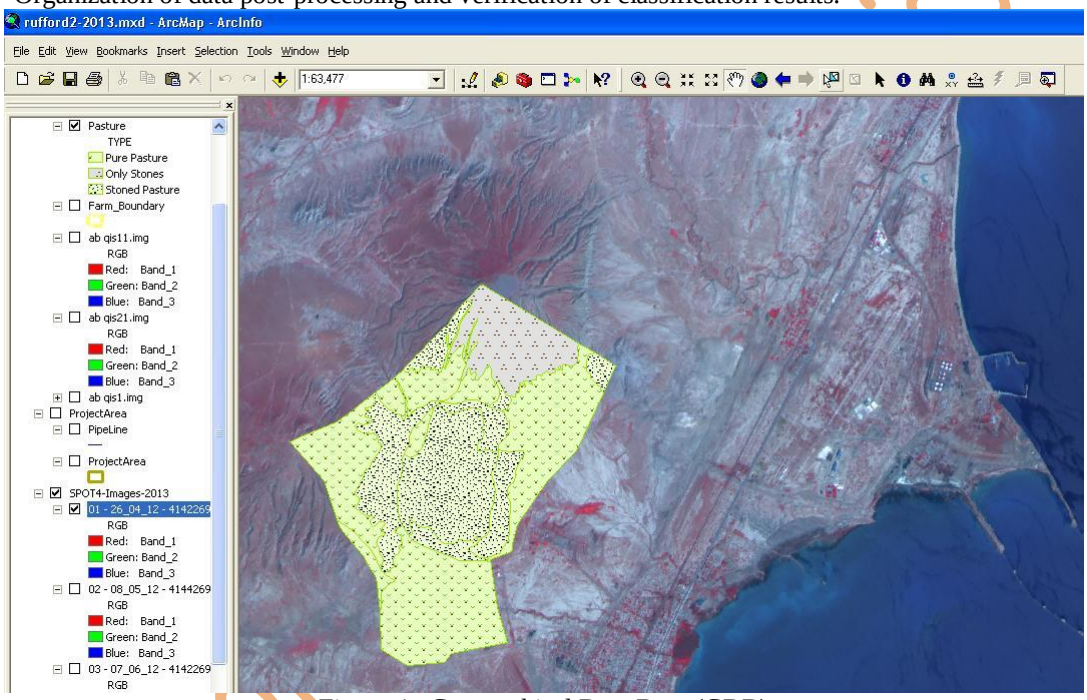

Figure 4: Geographical Data Base (GDB)

Creation of Map of current pasture usage

Purpose: To provide data on the extent of pasturelands in the Gobustan National Park for rare vegetation conservation.

Digitized data layers were converted into a collection of several shapefiles. The attributes of the shapefiles were previously designed for the usage of the study in the project region of the Gobustan National Park. The shapefiles are containing polygons such as Pasture areas: *Pure Pastures* and *Stony Pasture* (Figure 5). Other point geometry based files are containing individual pasture related constructions [14].

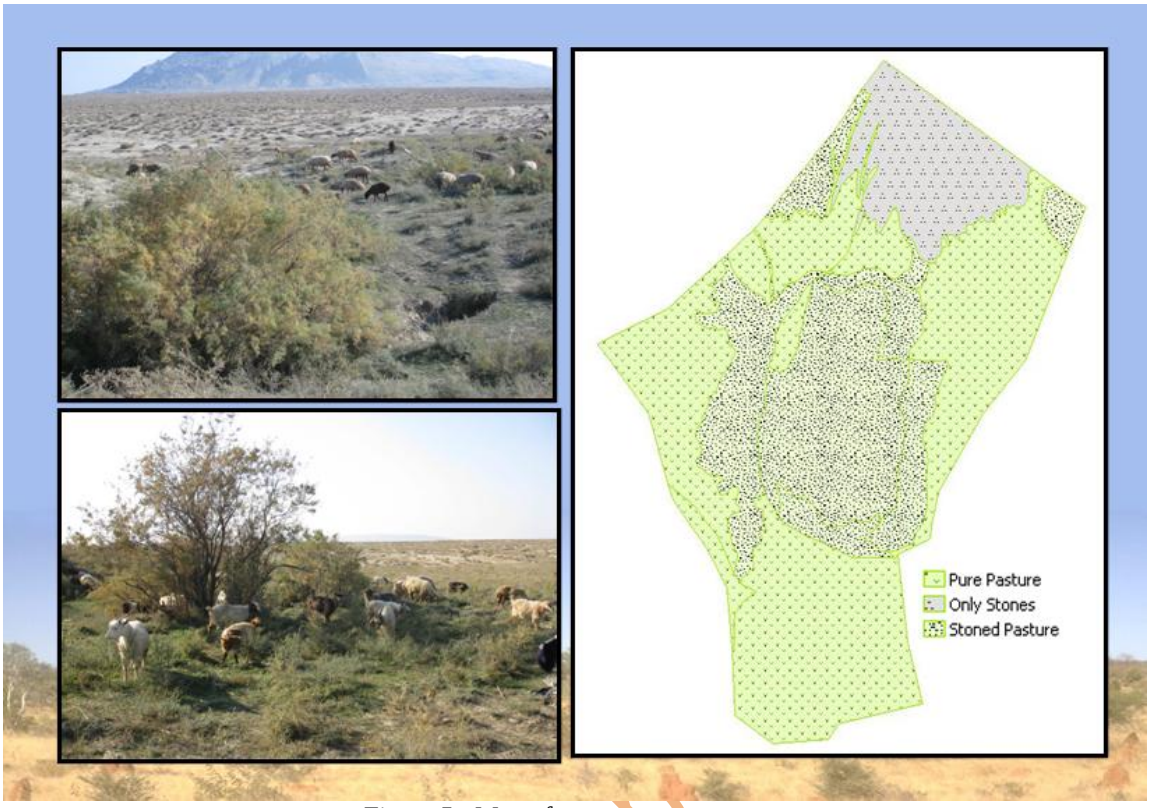

Figure 5: Map of current pasture usage

Samples set of the rare vegetation classes

The supervised approach to pixel labeling requires the user to select representative training data for each of a predefined number of classes. Also supervised classification techniques use prior knowledge about the field, which is very much helpful in getting better classification [15].

Creation of Training Sites for classification includes:

- Point taken in field with GPS
- Digitized at Computer to create training site
- Training sites used to identify habitat classification (Figure 6).

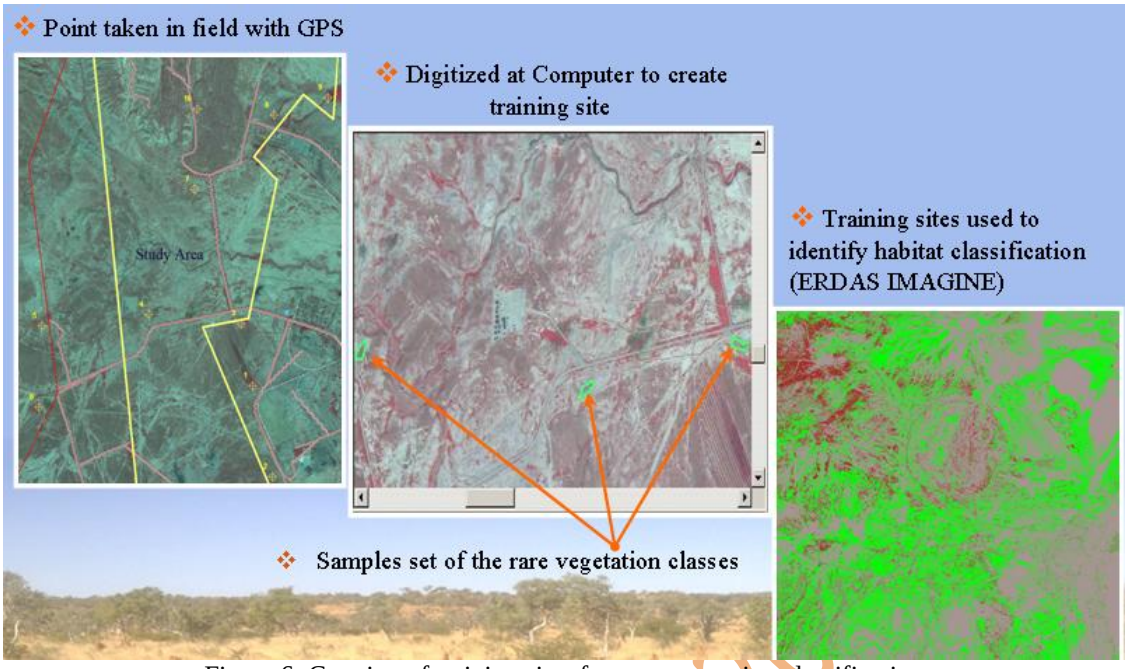

Figure 6: Creation of training sites for rare vegetation classification

RESULTS AND DISCUSSION

Creation of Specialized GIS Environment

Specialized GIS for managing project activities during its lifecycle was applied and would be used for:

- Spatial data management as a whole;
- Optimal distribution of training and test sites for classification process;
- Performing post classification processing and various spatial analyses;
- Making thematic maps and generation of reports.

We have developed and built a toolset in Core GIS for managing/automating all processes during the project lifetime.

The Development process involves two steps with the following outputs:

1. Creation of the tools for collecting/gathering training and test sets of samples.
2. Creation of tools for designing, learning and testing of classifiers and performing classification on real data.

This software we called *Specialized GIS Environment* for solving applied tasks using RS data and classifiers.

Development/Extending the Digital Framework

Development of classifier's software

As the development tool we used Integrated development environment (IDE) Visual Studio .NET 2005 and programming language Visual C#, in which we developed classification toolset for ArcGIS. This toolset consisted of tools functioning within ArcGIS ArcMap program. The toolset also included the tools for extracting training and test sets of samples from imageries and has the capability to perform the following activities:

- Creating training and test signatures from imagery
- Performing statistical tests on separability and overlapping of signatures
- Graphical representation of results of statistical tests
- Performing classification on real data

Below is a general of "Classification toolbar" on the ArcMap Window (Figure 7).

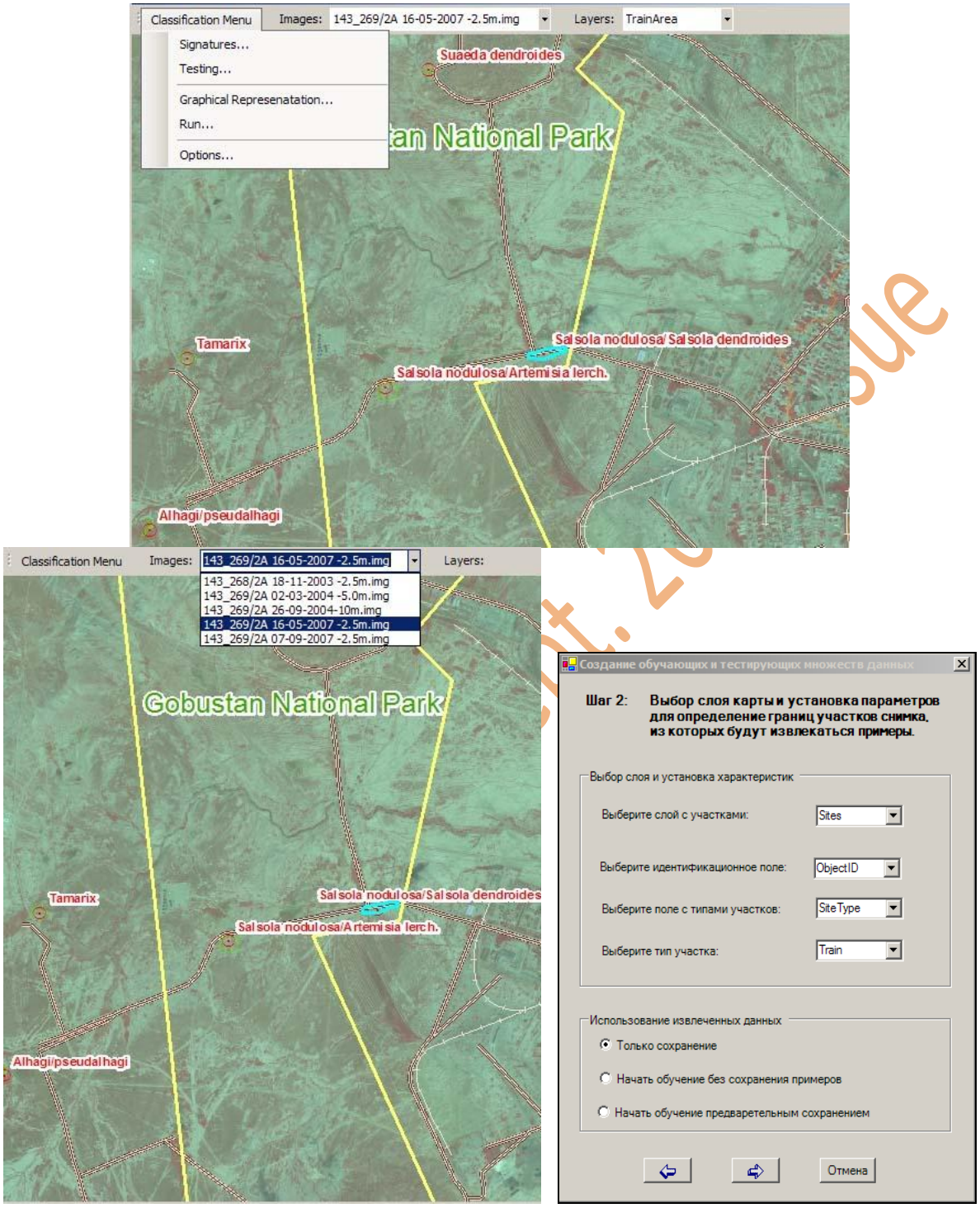

Figure 7: Specialized GIS Environment

The Tools realizing these functionalities made mainly in the form of "Wizard" that consisted of finite number of steps with providing information in a dialog in window containing a control block panel. Through the Dialog Window each user, step-by-step, through an entire process, can select or determine values of set logically correlation parameters. As example below is the main Dialog of Wizard which is activated by the tool "*Create training and test signatures*".

CONCLUSIONS

The aim of this study was to design the Geographical Data Base and creation of Specialized GIS Environment. The main pasture types, summer and winter pastures were distinguished.

Map of current pasture usage was created to to provide data on the extent of pasturelands in Gobustan National Park for rare vegetation conservation. The tools for designing and learning, testing of classifiers and performing classification on real data were developed. A Specialized GIS was used as software environment for performing workflow comprising of jobs connected with collecting of samples, hosting of classifier training and producing software as well as classification results analysis.

Remote sensing is a suitable tool for pasture inventory in the Gobustan. 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.
The SPOT 4 images proved to be a useful data source in the mapping of pastures in Gobustan. The SPOT4 images used in this study was taken in May and late August, at a time when the summer pastures were already heavily grazed.

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