REPUBLIC OF TURKEY
Ministry of Environment and Forestry
General Directorate of Afforestation and Erosion Control
Head of Planning Department

Middle East Watersheds Monitoring and Evaluation Project

Israel	Jordan	Palestinian Authority	Turkey	United States

REPORT FOR MALATYA KIZILOZ MICROCATCHMENT MONITORING VIA SATELLITE DATA

March 2005

ANKARA

MIDDLE EAST WATERSHEDS
MONITORING AND EVALUATION PROJECT

REPORT FOR
MALATYA KIZILOZ MICROCATCHMENT MONITORING VIA SATELLITE DATA

By

Ismail BELEN
Forest Engineer (Msc.)
Head of Department
Turkey Project Manager

Dr. Gürsel KÜSEK
Agriculture Engineer
Principle Investigator

Ismail Hakkı ATABAY
Forest Engineer
Principle Investigator

PREFACE

The Middle East Watershed Monitoring and Evaluation Project, an environmental component of the Middle East peace process, has been underway since 1999. This project represents a collaborative research effort among partners in Israel, Jordan, Palestinian Authority, Turkey, and the United States. It intends to:

- Monitor and evaluate the effectiveness of watershed management practices in preventing erosion and increasing the efficiency of water use in arid and semi-arid watershed pilot programs;
- Evaluate the biophysical measurements appropriate for evaluation of operational watershed management practices implemented for erosion control and biomass production in arid and semi-arid regions:
- Demonstrate effective practices for forest and grassland management using pilot watershed programs.
- The participating countries support the project with in kind resources; additional financial assistance comes from several US Government sources. **The USDA Forest Service Inventory and Monitoring Institute** provides technical and administrative management for this project.

The project has been implemented different areas in above-mentioned countries. In Turkey, the Kizilöz Microcatchment has been chosen for this purpose.

In this study, IKONOS high resolution satellite data were used for the definition of the land use and determination of the change detection between 2002 and 2004.

Ministry of Environment and Forestry, General Directorate of Afforestation and Erosion Control, is grateful to the Government of the United States **(USDA Forest Service International Programs)** for its financial support to this work.

March 18, 2005

Mustafa YÜKSEK
Director General
General Directorate of Afforestation and Erosion Control
Ministry of Environment and Forestry
Republic of Turkey

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1. INTRODUCTION

Remote sensing satellite imagery has been used since 1972. The first remote sensing satellite was Landsat1 MSS (Multi Spectral Scanner). The sensor technology improved extremely during this period. Nowadays many information categories for the wide areas can be extracted from these satellite data such as land cover and land use. Increasing sensor technology gives us 0.6,1 meter ground resolution such as QUICKBIRD and IKONOS satellite data.

In this study IKONOS high resolution satellite data were used for the definition of the land use and determination of the change detection between 2002 and 2004.

In this work, for the classification and detection land use and land cover data is given in this report. For this purpose 10km by 10 km 1 meter resolution IKONOS satellite data in 2002 and 2004 were used. This satellite images are shown in Figures 1 and 2.

IKONOS satellite has 4 bands 4 meter resolution multispectral and 1 meter resolution panchromatic data. Detailed information for these bands is given in Table 1.

Table 1. IKONOS satellite bands and specifications for each band

Band	wavelength (µm)	Resolution (meter)	Spectrum
Pan	0.525-0.928	1	Visual-NearInfraRed
1	0.445-0.516	4	Blue-Green
2	0.506-0.595	4	Green
3	0.632-0.698	4	Red
4	0.757-0.853	4	Near IR

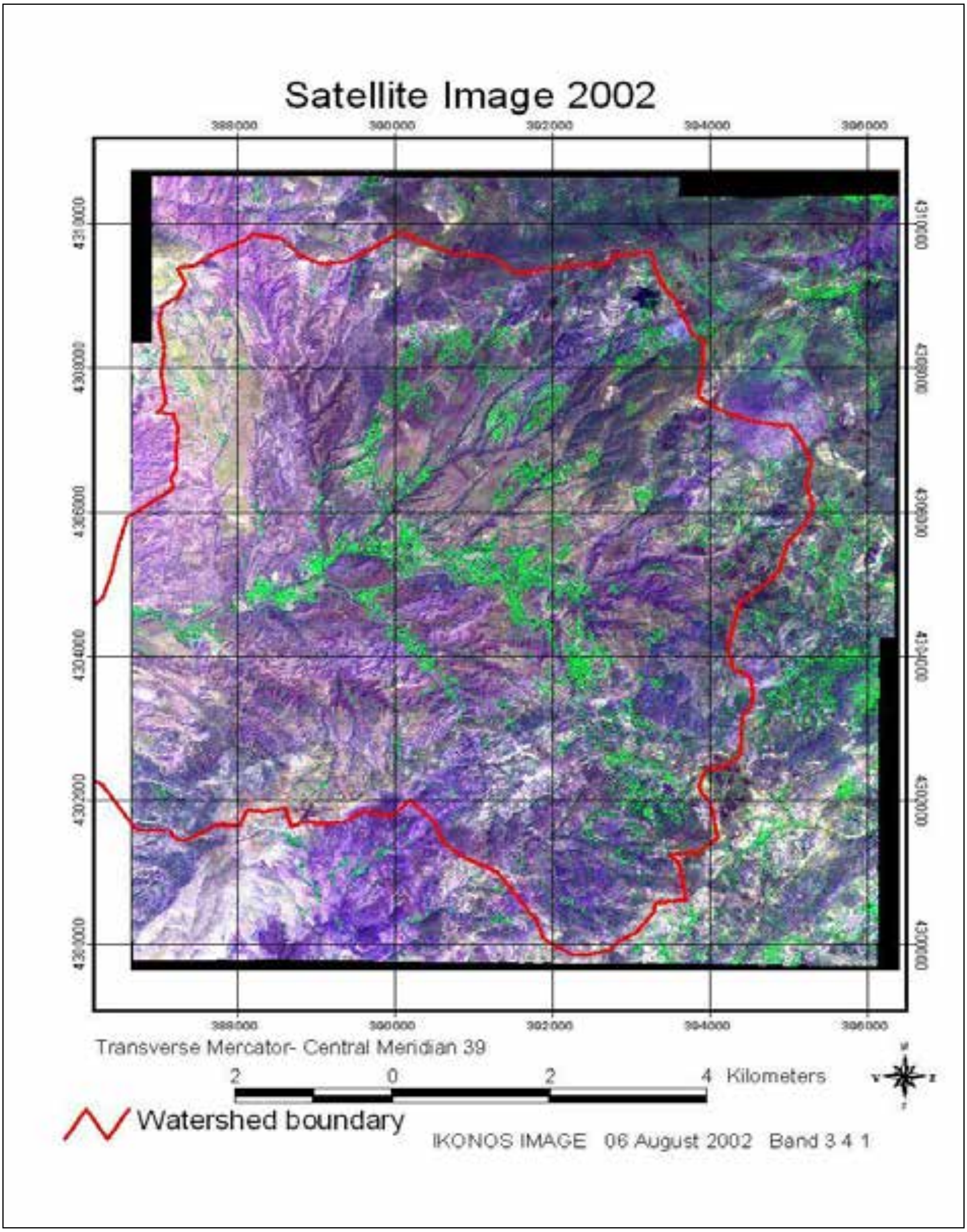


Figure1. Orthorectified Ikonos Image in 06/08/2002.

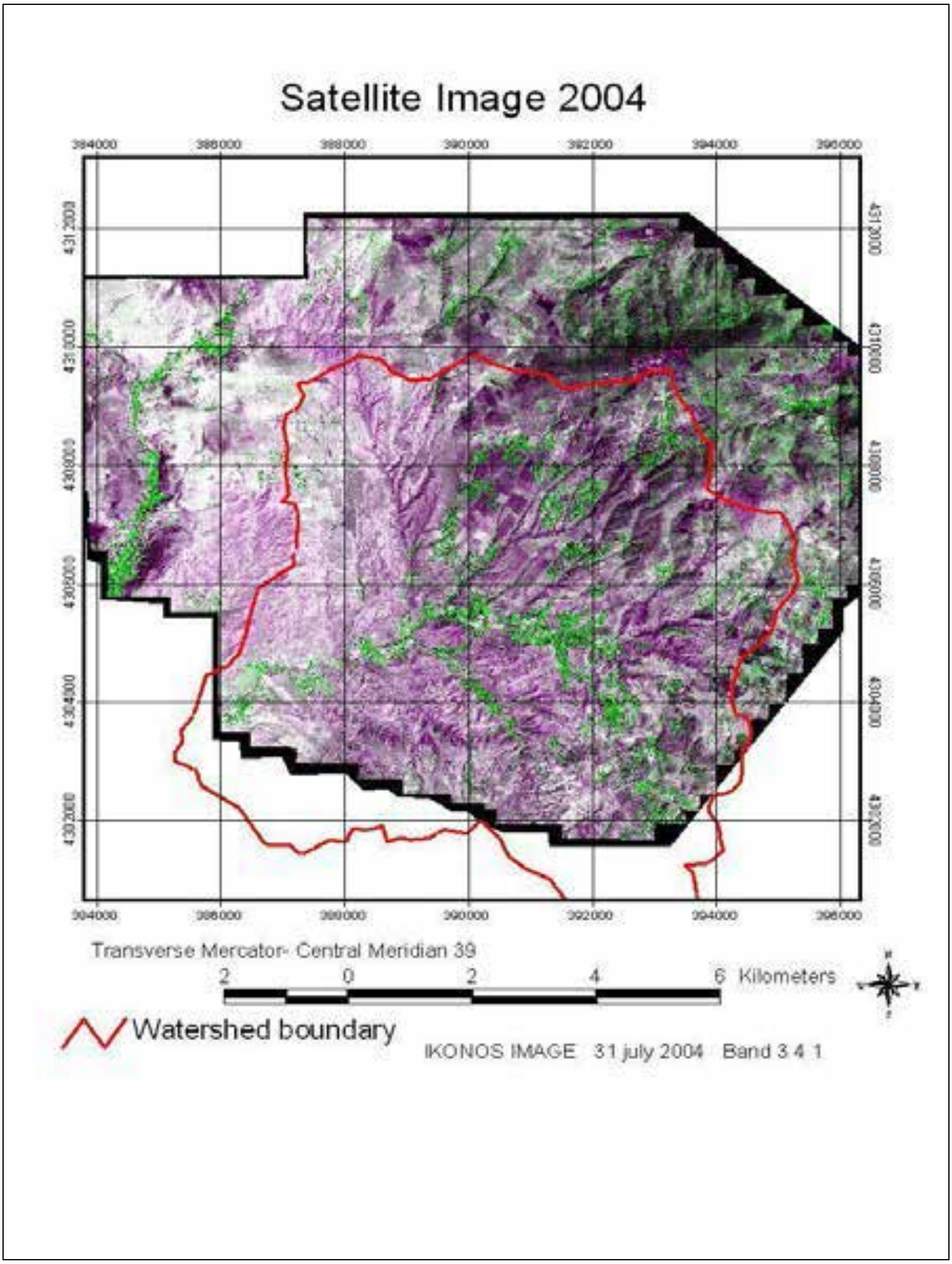


Figure 2. Orthorectified Ikonos Image in 31/07/2004.

This task includes determination of the vegetation and classification of the satellite images to find the proper information for extracting the required information about land use and land cover. IKONOS images gives us chance to determine a lot of characteristics of the earth surface such as urban, vegetation, grass, agricultural area, forest, water, marsh, arid area, geological structure etc. IKONOS multispectral imagery can support these classes because the satellite has 4 different type of sensor and these sensors are sensing waves in different wavelengths, which are reflected from the earth surface in different types. Each image, which is provided by different sensor, is called as band. 3 band combination of the imagery which is band 3 4 1 combinations will be enough for this project to extract the information for land cover and land use classes and vegetation. These classes are given in Table 3 in detail. sifications of the imagery are performed using some image processing techniques. Detailed information for these techniques is given in Section 4. All the image processing steps are shown in figure 2.

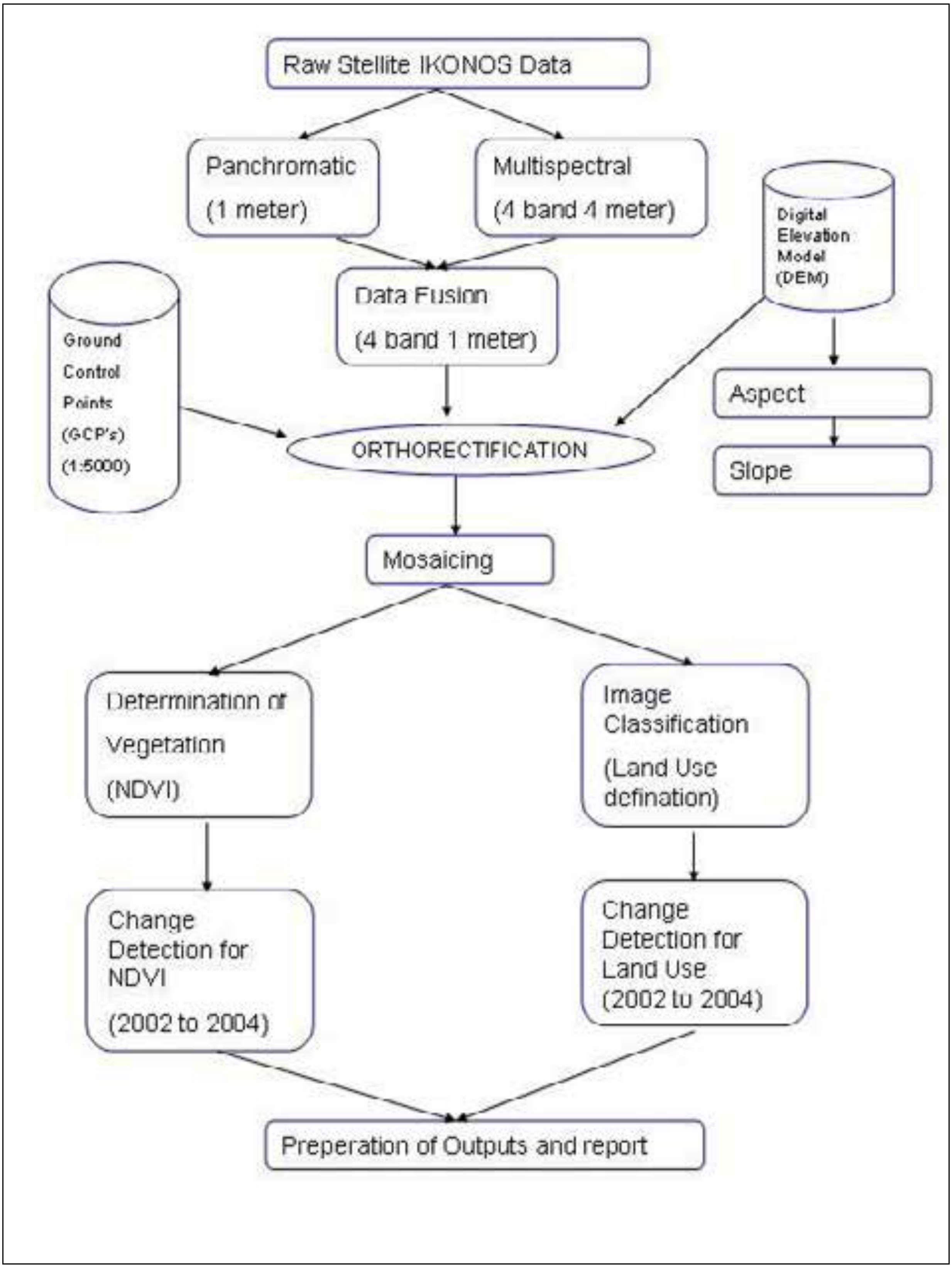


Figure 3. Flow of the Image Processing techniques.

2. DATA AND PREPARATION

2.1. Data Fusion

In this method performs data fusion of an input RGB color image on an input file with a black-and-white intensity image. The result is an output RGB color image with the same resolution as the intensity image. If the input and output files are different resolution, the input RGB color image is resampled using the specified resampling method.

In the IKONOS images 3 RGB color images (band 3 4 1 combination) has 4m. resolution and 1m.resolution panchromatic for intensity band are used as input. Consequences, fused data has 1m. resolution and 3 band RGB color images. A sample 1 meter and 4 meter resolution fused image in Figure 3.

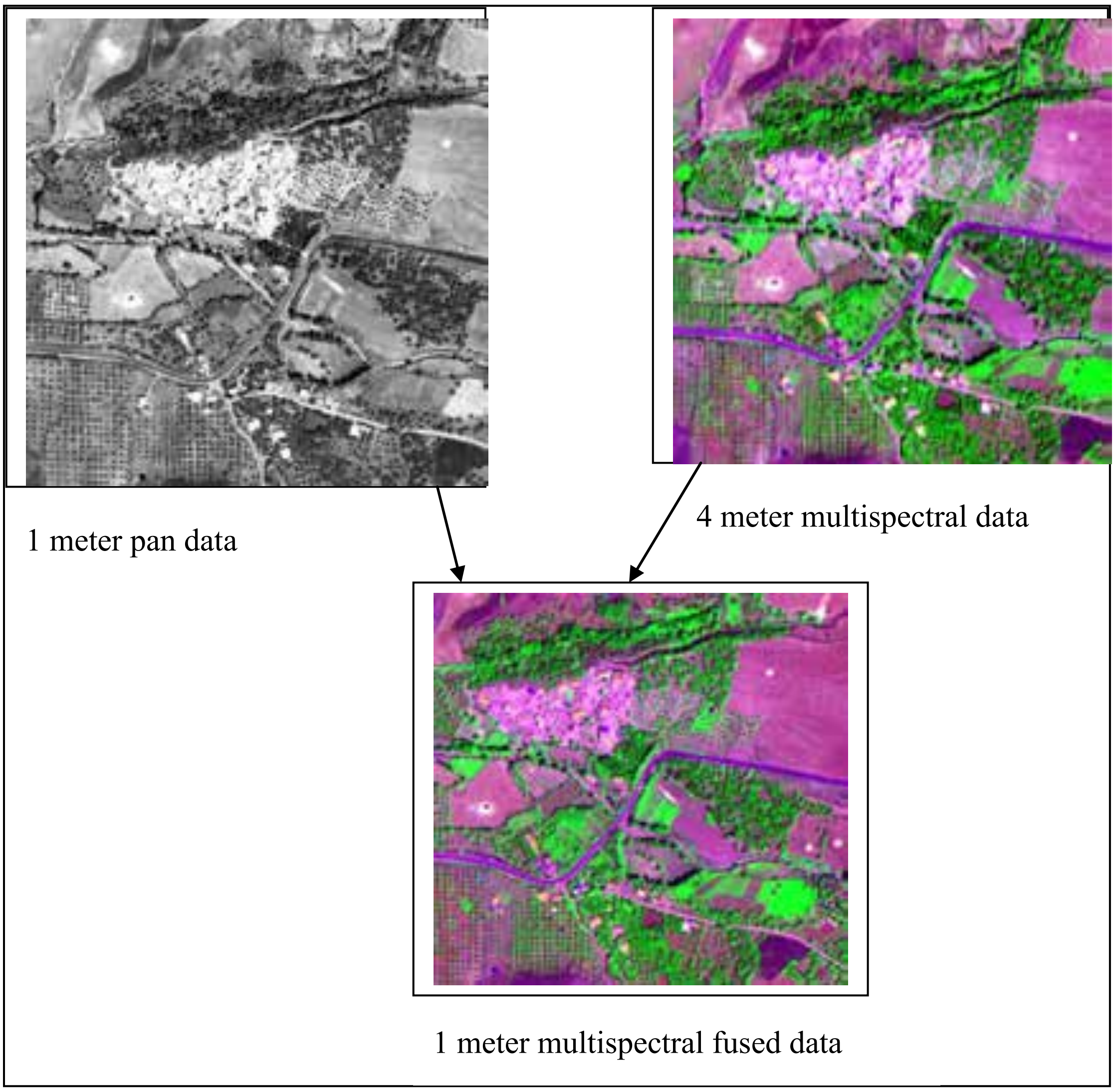


Figure4. Data fusion between high and low resolution.

2.2. Orthorectification

Totally 4 topographic contour maps (1/25.000) were merged and converted to shape file and projected using Transvers Mercator system ,Central meridian 39 and European 1950 DATUM. Digital Elevation Model (DEM), produced in ERDAS Imaging and PG Steamer Image Processing software from merged contours, has 5 m. grid size DEM. This DEM were used for the ortho-rectification of the images.

Ground control points (GCP) were collected from 1/5000 scale scanned topographical map sheets. 1:25.000 scale maps were used if 1/5000 scale maps were not exist in the coverage area

In the ortho-rectification nearest resampling method were applied. All statistical information is given in the table include RMS value. This RMS value is given in pixel (1pixel=1 meters). Statistical results are given in table.2 for orthorectification.

Table 2. Orthorectification statistics and gcp RMS in pixel.

Date and name of image	Total gcp number	XRMS	YRMS	General RMS
06/08/2002	22	3.68	2.06	4.21
31/07/2004 right	27	1.83	0.88	2.03
31/07/2004 left	23	1.02	0.84	1.32

3. METHODS

3.1. Delineation OF VEGETATION Cover

Topographical corrections applied to all images after orthorectification for flat area and hilly area reflection normalization. In the satellite images processing techniques some band ratio gives us to some special surface characteristics. For example differs of two different bands are called as „**index**" in general image processing, but in satellite or aerial image techniques if this index comes from Near infrared – Red regions of spectrum it takes as "**vegetation index (VI)**". Because green plants have chlorophyll and reflection is higher level in infrared bands. Thus, Vegetation index is differs of near infrared band and red bands. For the normalization of this data result of the vegetation index is divided to total of the two bands. Result is called "**Normalized Difference Vegetation Index (NDVI)"** and formulated as follow:

$$\textbf{NDVI} = \frac{\textbf{Near Infrared – Red (IKONOS band4 – band3))}}{\textbf{Near Infrared + Red (IKONOS band4 – band3))}}$$

NDVI are takes in 32 bit data vary –1 to +1 and positive values are represents vegetated and negative values are non-vegetated areas. For the interpretation, map and print these data can be scaled in to the 8 bit data as 0 to 200 varying values. Where –1 value goes to 0 and +1 value goes 200. More than 100 have vegetated and less then 100 nonvegetated areas. Sometimes this "100" threshold value goes up end down due to the sensor and atmospheric conditions. In our work this theshold goes 110. In these 8 bit data results can be threshold by the specialist as high dense, dense and low dense depends on the area characteristics. From the NDVI negative values water can be distinguished easily. As a result of NDVI value some special areas can be extracted and can be masked in the pre-classification input data. In figure 5 and figure 6 are seen NDVI for 2002 and 2004 respectively.

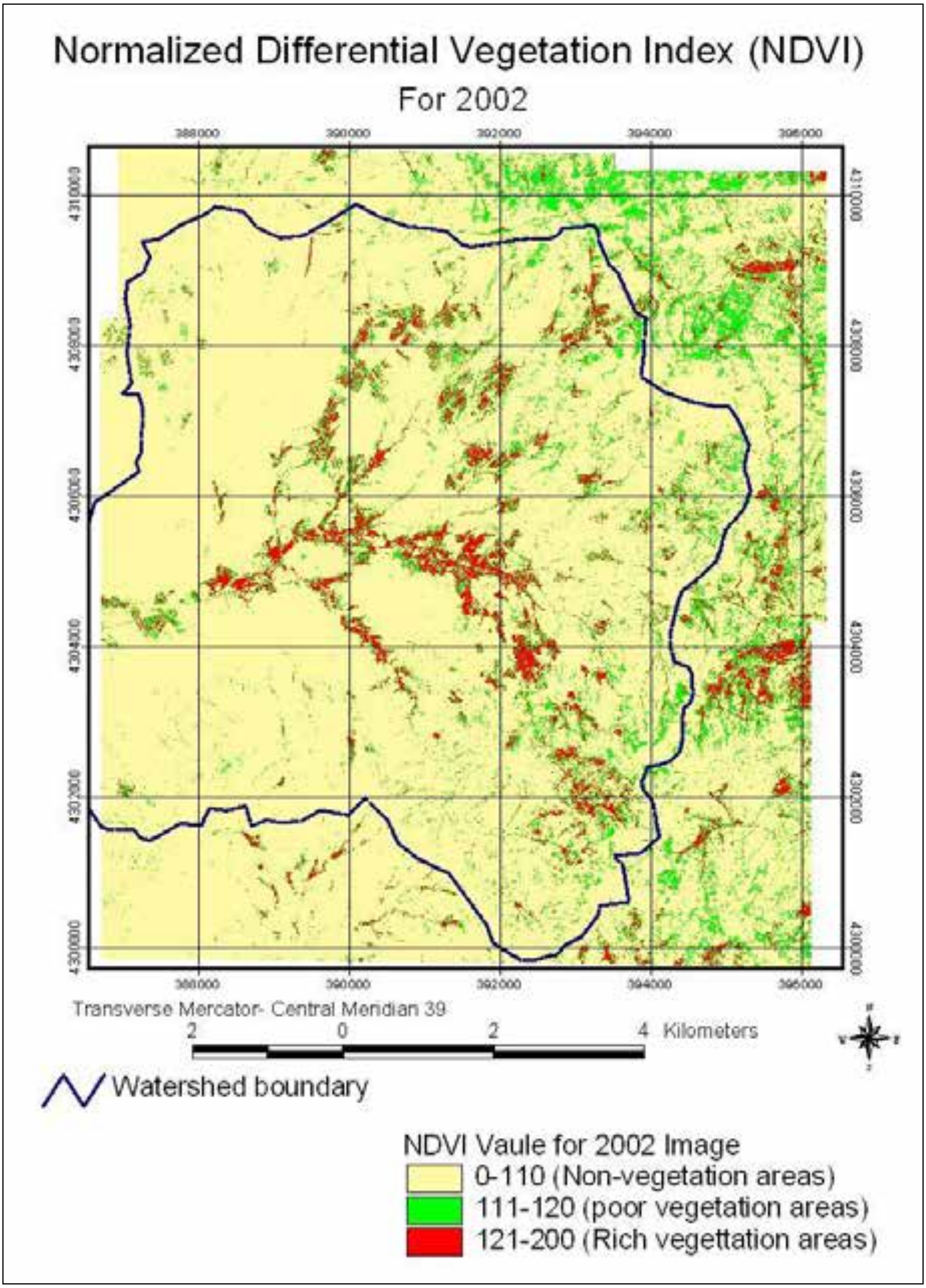


Figure 5. Normalized Differential Vegetation Index for 06/08/2002.

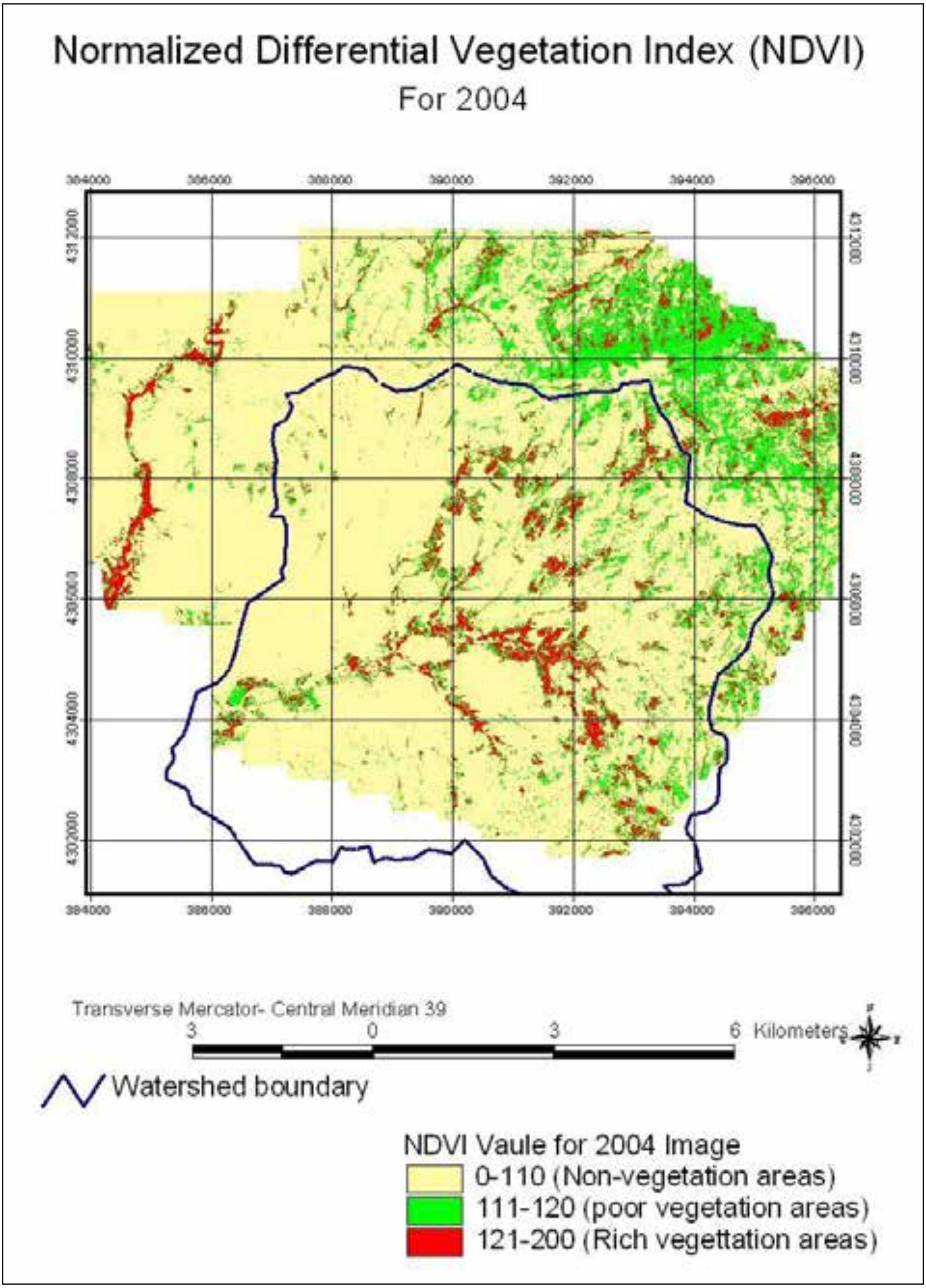


Figure 6.Normalized Differential Vegetation Index for 31/07/2004.

3.2. Classification procedure

For information extraction from satellite, visually interpretation is gives us to best accuracy. But this visual method takes too much time and need expertise. In this case there is a lot of algorithm for extraction information.

Two types of classification methods are being used generally. These are supervised and unsupervised classifications. Unsupervised classification is performed for separating the classes according the needs. Unsupervised classification is generally used for determining the main classes and is used as a base for supervised classification.

3.2.1. Unsupervised classification

In *unsupervised classification* any individual pixel is compared to each discrete cluster to see which one it is closest to. A map of all pixels in the image, classified as to which cluster each pixel is most likely to belong, is produced in black and white or more commonly in colors assigned to each cluster. This then must be interpreted by the user as to what the color patterns may mean in terms of classes, etc. that are actually present in the real world scene; this requires some knowledge of the scene's feature/class/material content from general experience or personal familiarity with the area imaged. In *supervised classification* the interpreter knows beforehand what classes, etc. are present and where each is in one or more locations within the scene. These are located on the image, areas containing examples of the class are circumscribed (making them training sites), and the statistical analysis is performed on the multiband data for each such class. Instead of clusters then, one has class groupings with appropriate discriminate functions that distinguish each (it is possible that more than one class will have similar spectral values but unlikely when more than 3 bands are used because different classes/materials seldom have similar responses over a wide range of wavelengths). All pixels in the image lying outside training sites are then compared with the class discriminates, with each being assigned to the class it is closest to - this makes a map of established classes (with a few pixels usually remaining unknown) which can be reasonably accurate but some classes present may not have been set up; or some pixels are misclassified.

In an unsupervised classification, the objective is to group multiband spectral response patterns into clusters that are statistically separable. Thus, a small range of digital numbers (DNs) for, say 3 bands, can establish one cluster that is set apart from a specified range combination for another cluster (and so forth). Separation will depend on the parameters we choose to differentiate. This process can be visualized with the aid of this diagram for four classes: shown in figure 5.

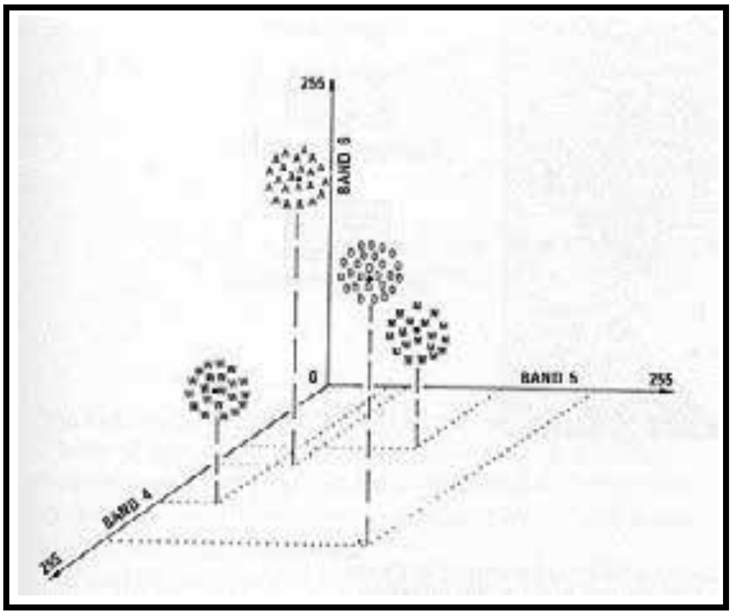


Figure 7.Unsupervised classification parameters for different classes

These clusters can be modified, so that their total number can vary arbitrarily. When the separations are done on a computer, each pixel in an image is assigned to one of the clusters as being most similar to it in DN combination value. Generally, in an area within an image, multiple pixels in the same cluster correspond to some (initially unknown) ground feature or class so that patterns of gray levels result in a new image depicting the spatial distribution of the clusters. These levels can then be assigned colors to produce a cluster map. The trick then becomes one of trying to relate the different clusters to meaningful ground categories. This is done by either being adequately familiar with the major classes expected in the scene, or, where feasible, by visiting the scene (**ground truthing**) and visually correlating map patterns to their ground counterparts. Since the classes are not selected beforehand, this latter method is called Unsupervised Classification. A sample-classified from watershed image is given in Figure 6.

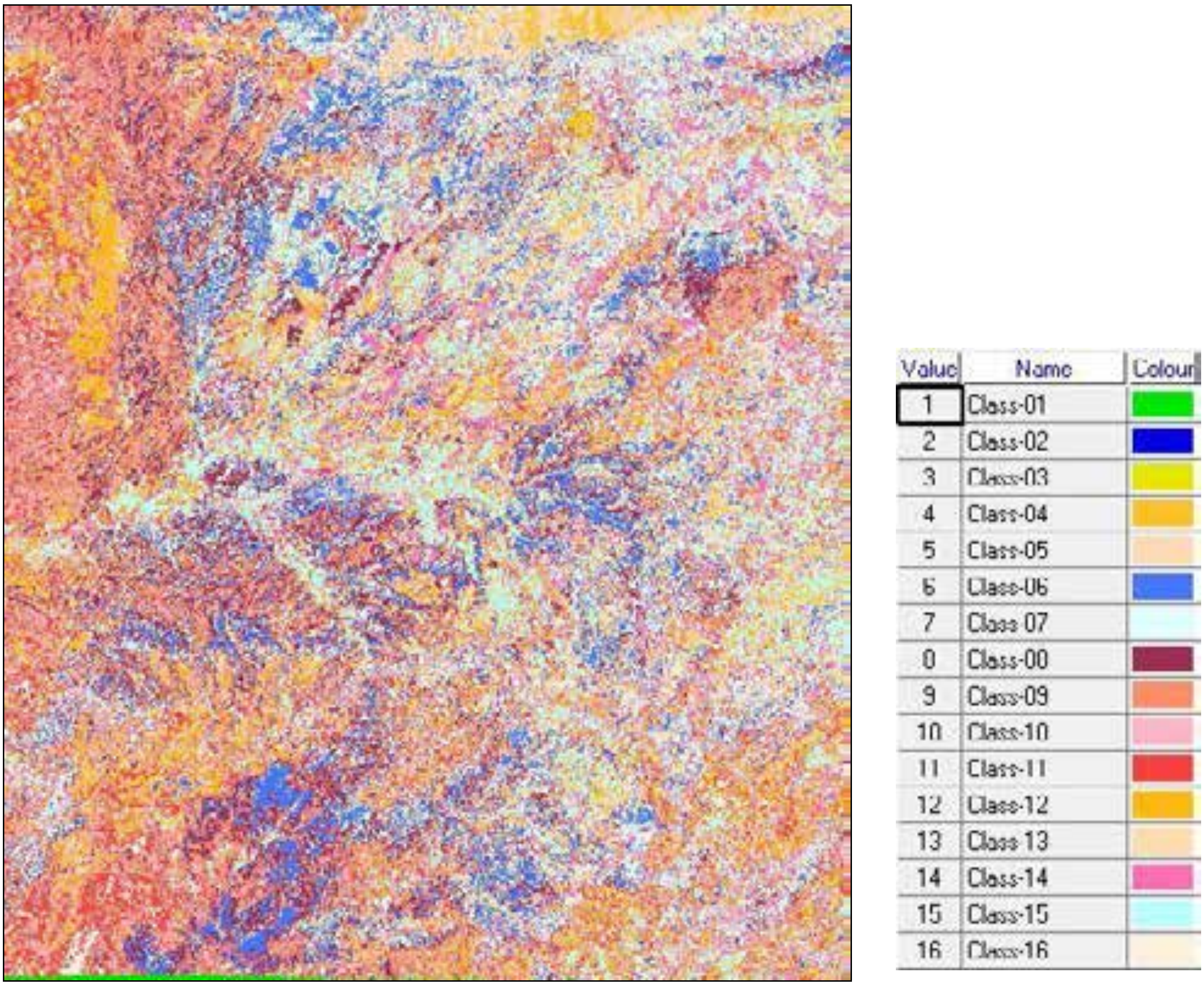


Figure 8. An example for unsupervised classification for 06/08/2002 images

As a summary, unsupervised classification is too much of a generalization and that the clusters only roughly match some of the actual classes. Its value is mainly as a guide to the spectral content of a scene to aid in making a preliminary interpretation prior to conducting the much more powerful supervised classification procedures.

3.2.2. Supervised classification

Supervised classification is much more accurate for mapping classes, but depends heavily on the cognition and skills of the image specialist. The strategy is simple: the specialist must recognize conventional classes (real and familiar) or meaningful (but somewhat artificial) classes in a scene from prior knowledge, such as, personal experience with the region, by experience with thematic maps, or by on-site visits. This familiarity allows the specialist to choose and set up discrete classes (thus supervising the selection) and the, assign them category names. The specialists also locate training sites on the image to identify the classes. **Training sites** are areas representing each known land cover category that appear fairly homogeneous on the image (as determined by similarity in tone or color within shapes delineating the category). Specialists locate and circumscribe them with polygonal boundaries drawn (using the computer mouse) on the image display. For each class thus outlined, mean values and variances of the DNs for each band used to classify them are calculated from all the pixels enclosed in the site. More than one polygon can be established for any class. When DNs are plotted as a function of the band sequence (increasing with wavelength), the result is a **spectral signature** or spectral response curve for that class. In reality the spectral signature is for all of the materials within the site that interact with the incoming radiation. Classification now proceeds by statistical processing in which every pixel is compared with the various signatures and assigned to the class whose signature comes closest. A few pixels in a scene do not match and remain unclassified, because these may belong to a class not recognized or defined.

Total 6 classes desired for this work. This class required for determination of land use accordingly watershed rehabilitation and its result. This 6 class defined in table 3.

Table 3. Satellite-derived clutter: Proposed Class Descriptions

Class No	Class Name	Class Description
1	Multiyear vegetation/Trees	Forest, river base trees, multiyear trees, fruits
2	Annual Vegetation	Annual agricultural green areas, green grass
3	Range Land	Non green range land
4	Residue	Agricultural residue, dried vegetation, agricultural dry residue and waste harvested land etc
5	Fallow	Cultivated but not planted areas
6	Other/Mixed	Resident, road, pave, rocky areas, bare areas and water.

In the image processing techniques there are too many different supervised classification algorithm and process but two of them largely being used.

Minimum Distance Classification: Minimum distance classification is a method for supervised classification by producing the classes using the routine image processing algorithm. DNs in multidimensional band space to organize the pixels into the classes, which had been choose**.** Each unknown pixel is then placed in the class *closest* to the mean vector in this band space. The resulting classification image consists of different levels, each representing a class, to which can be then assigned any color on the computer.

Maximum Likelihood Classification: In this method, multiband classes are derived statistically and each unknown pixel is assigned to a class using the maximum likelihood method. Each pixel goes nearest spectral likelihood training ares clases. In this project almost all frames and all classes extracted by using Maximum Likelihood classification techniques due to the better results.

All desired land use are shown in figures 9 and 10 for 2002 and 2004 images respectively

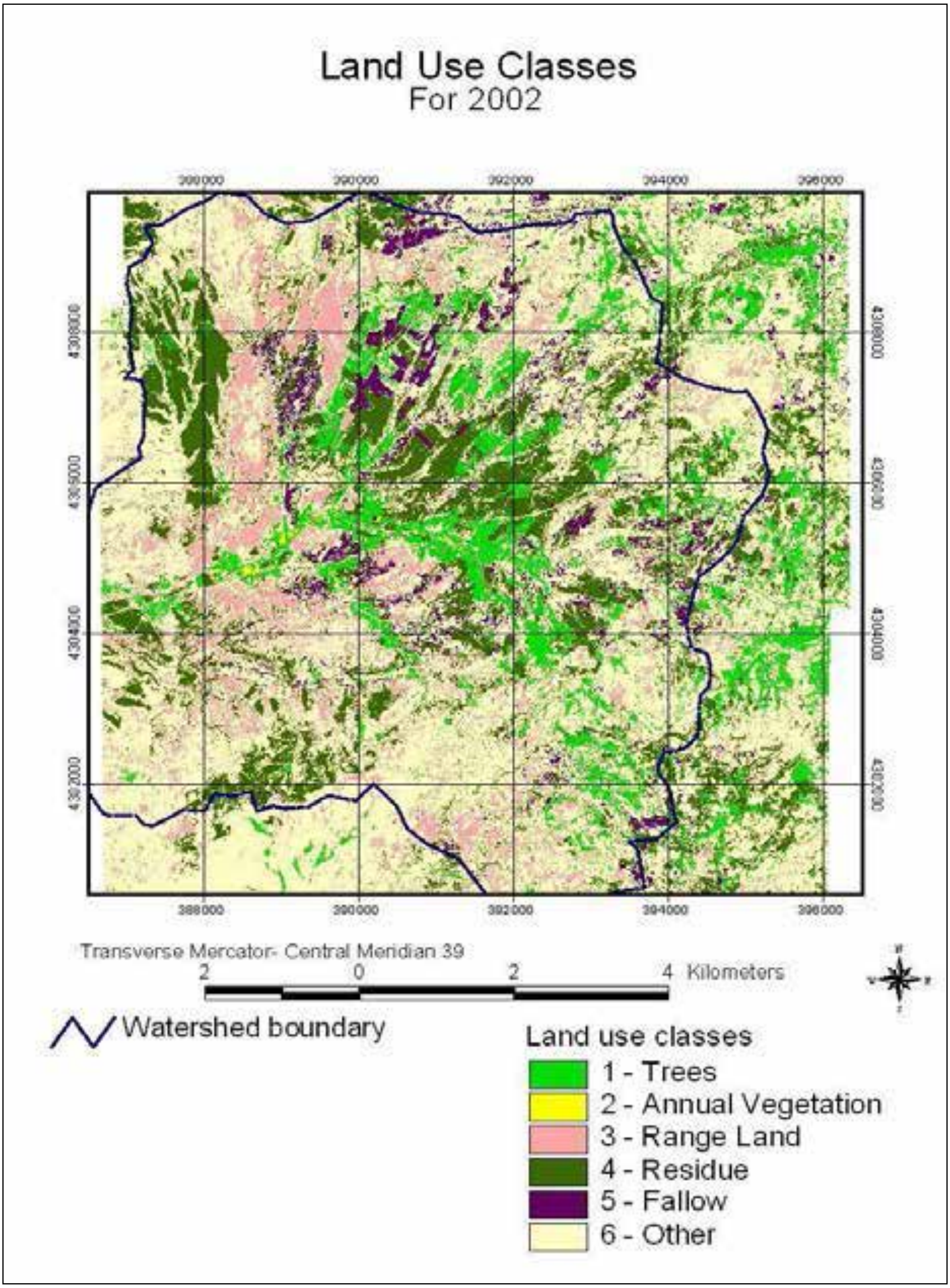


Figure 9. Land use classes for 06/08/2002.

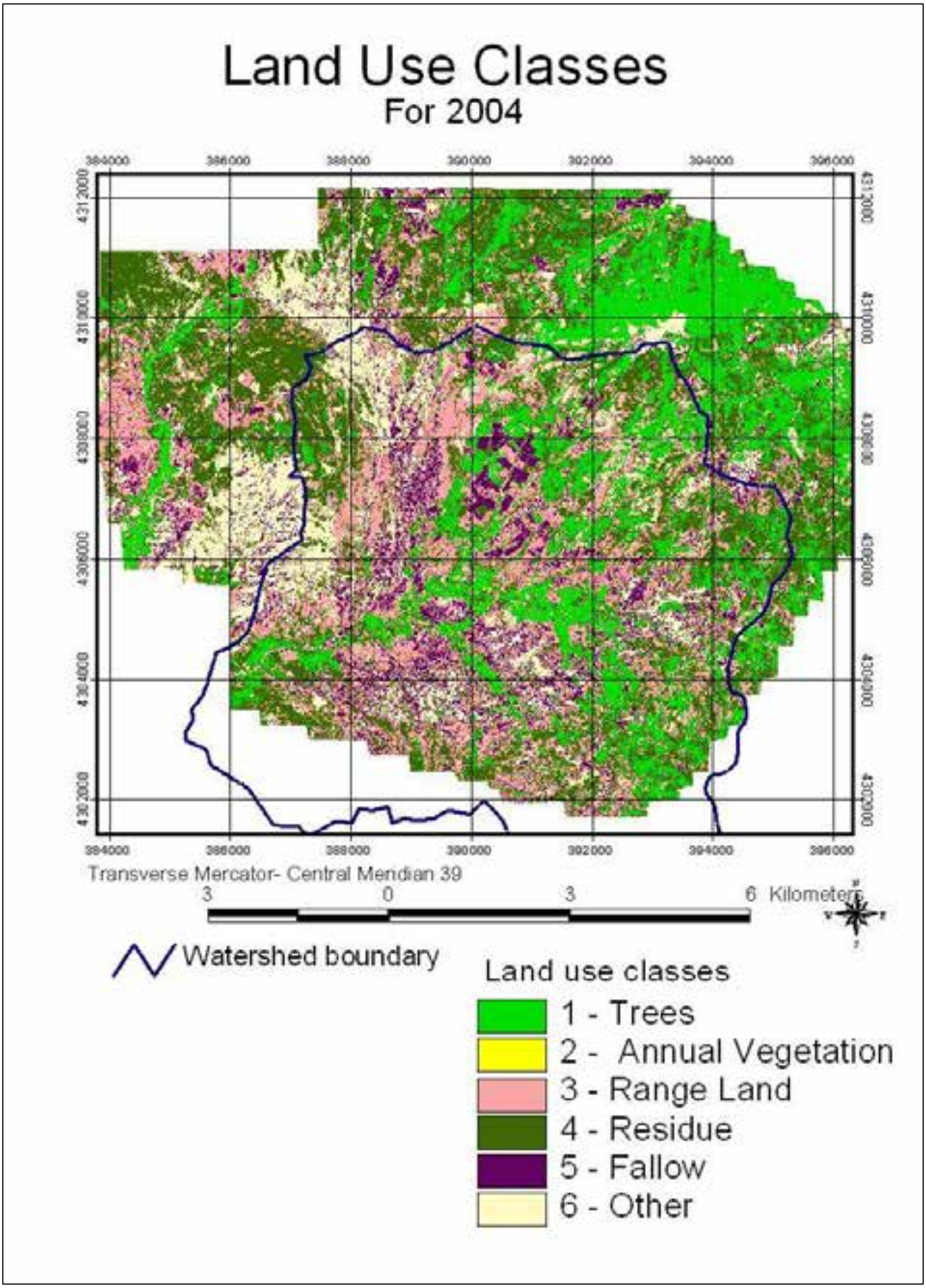


Figure 10.Land use classes for 31/07/2004.

4. ANALYSIS

4.1. Change Detection for Vegetation

Determination of the annual change can be measure in –situ measurement. But for large area this will take too much time and expensively. Satellite data can supply time and cost-efficient opportunity for this kind of large area.

Acquired satellite data in different time can be visually interpreted. Visually interpretation is better than the automated or semi automated classification. But visually interpretation is need for a long time. Especially this kind of high resolution satellite data gives more capability for visual interpretation. Because all detail information represent in 1 meter resolution.

In this section NDVI calculated for 2002 and 2004 images. Both images not overlap completely thus change detection applied only overlapped area. Then different of two NDVI gives us to change detection according to vegetation cover and from class to.
From class to class changing pixel by pixel is given in table 4. Change detection also shown in figure 8.

According to visual change detection some special areas selected and sampled in figure 10.a, 10.b and 10.c.

Table 4. Change detection from NDVI class to class and their area as pixels on the overlaping area.

From NDVI to NDVI	number of pixels	Percentage
No vegetation to high vegetation	506536	0.8
No vegetation to low vegetation	3854575	6.3
No change for No vegetation	47213162	77.7
Low vegetation to high vegetation	3095796	5.1
No change for low vegetation	1346040	2.2
Low vegetation to No vegetation	1111239	1.8
No change for high vegetation	2765962	4.6
High vegetation to low vegetation	654344	1.1
High vegetation to No vegetation	231736	0.4
Total Area	60779390	100.0

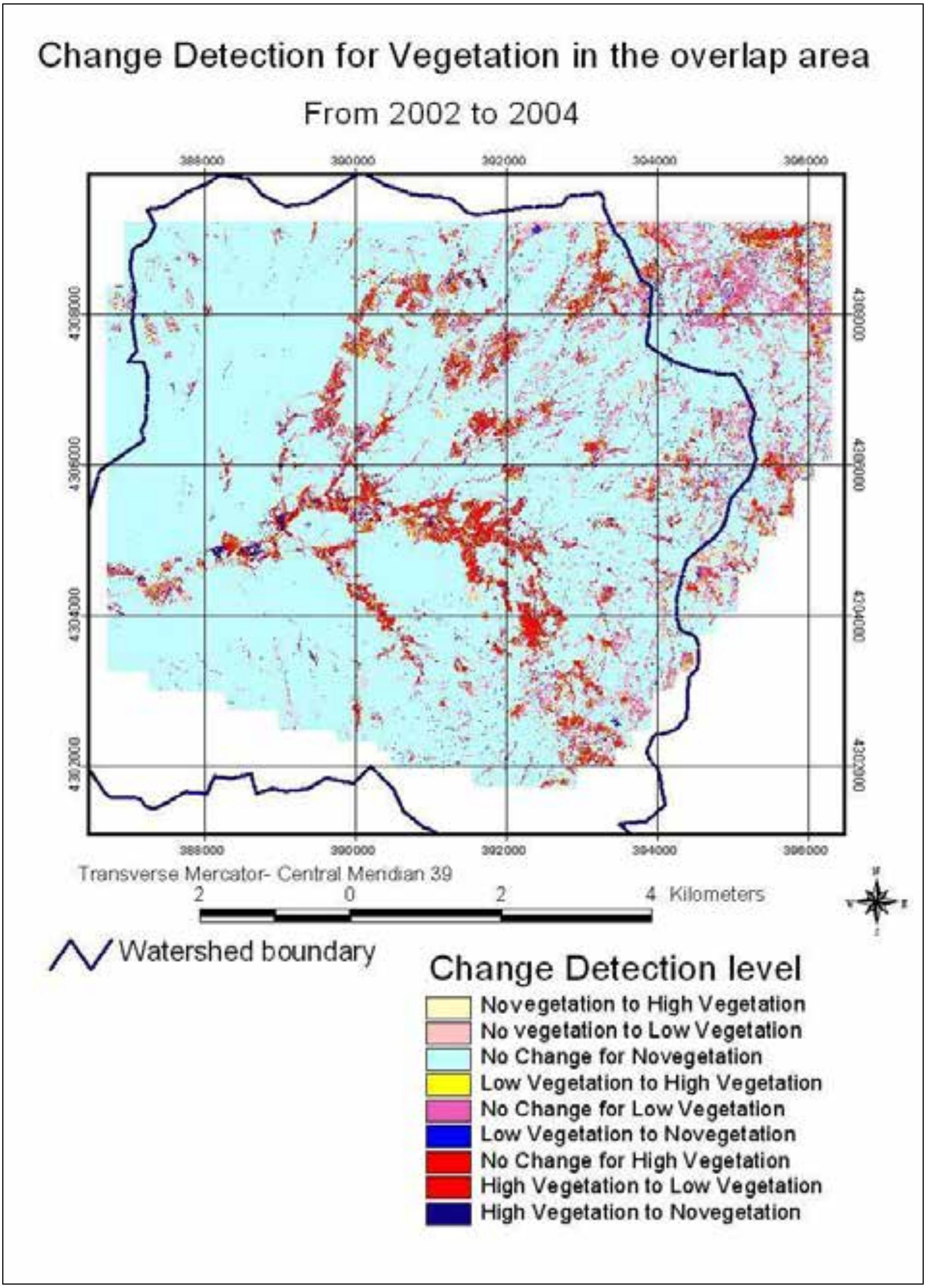


Figure 11. Change detection for Vegetation according to NDVI

4.2. Change Detection for Land Use Classes

Change detection applied only overlapped area from 2002 to 2004. In the 2002 images each classes number multiplied by 10 so confusing omitted from the result. In this section change detection areas determined according to land use classes and summarized their statistics in table 5 and shown in figure 9. Where legend values are the number of subruction between ten times of 2002 and 2004 class numbers.

Table 5 Change detection ranges from Land use class to class

Legend value	From class to class	Number of pixel	Percentage
4	1to6	68039	0.112
5	1to5	23682	0.039
6	1to4	644565	1.061
7	1to3	94511	0.156
8	1to2	138515	0.228
9	1to1	5618568	9.250
14	2to6	1590	0.003
15	2to5	551	0.001
16	2to4	24659	0.041
17	2to3	9032	0.015
18	2to2	8571	0.014
19	2to1	46977	0.077
24	3to6	823140	1.355
25	3to5	1662832	2.737
26	3to4	1295477	2.133
27	3to3	3957193	6.515
28	3to2	272	0.000
29	3to1	80127	0.132
34	4to6	958621	1.578
35	4to5	1506816	2.481
36	4to4	5024825	8.272
37	4to3	4476170	7.369
38	4to2	6070	0.010
39	4to1	557503	0.918
44	5to6	655732	1.080
45	5to5	1196183	1.969
46	5to4	278729	0.459
47	5to3	834717	1.374
48	5to2	426	0.001
49	5to1	82918	0.137
54	6to6	6395738	10.529
55	6to5	2573853	4.237
56	6to4	10666105	17.559
57	6to3	5914193	9.736
58	6to2	20041	0.033
59	6to1	5096456	8.390
	Total	**60743397**	**100.000**

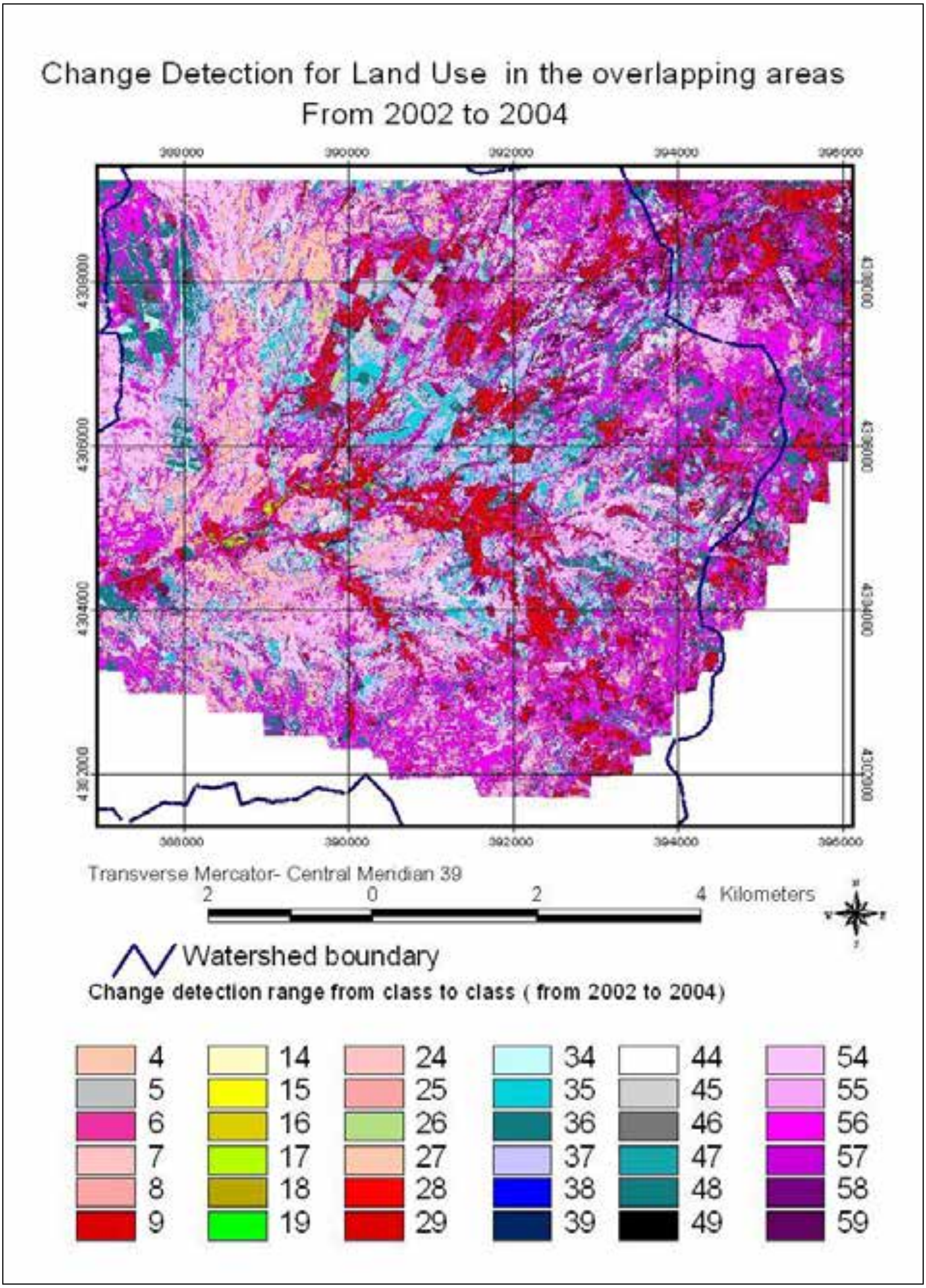


Figure 12. Change detection for Land use classes.

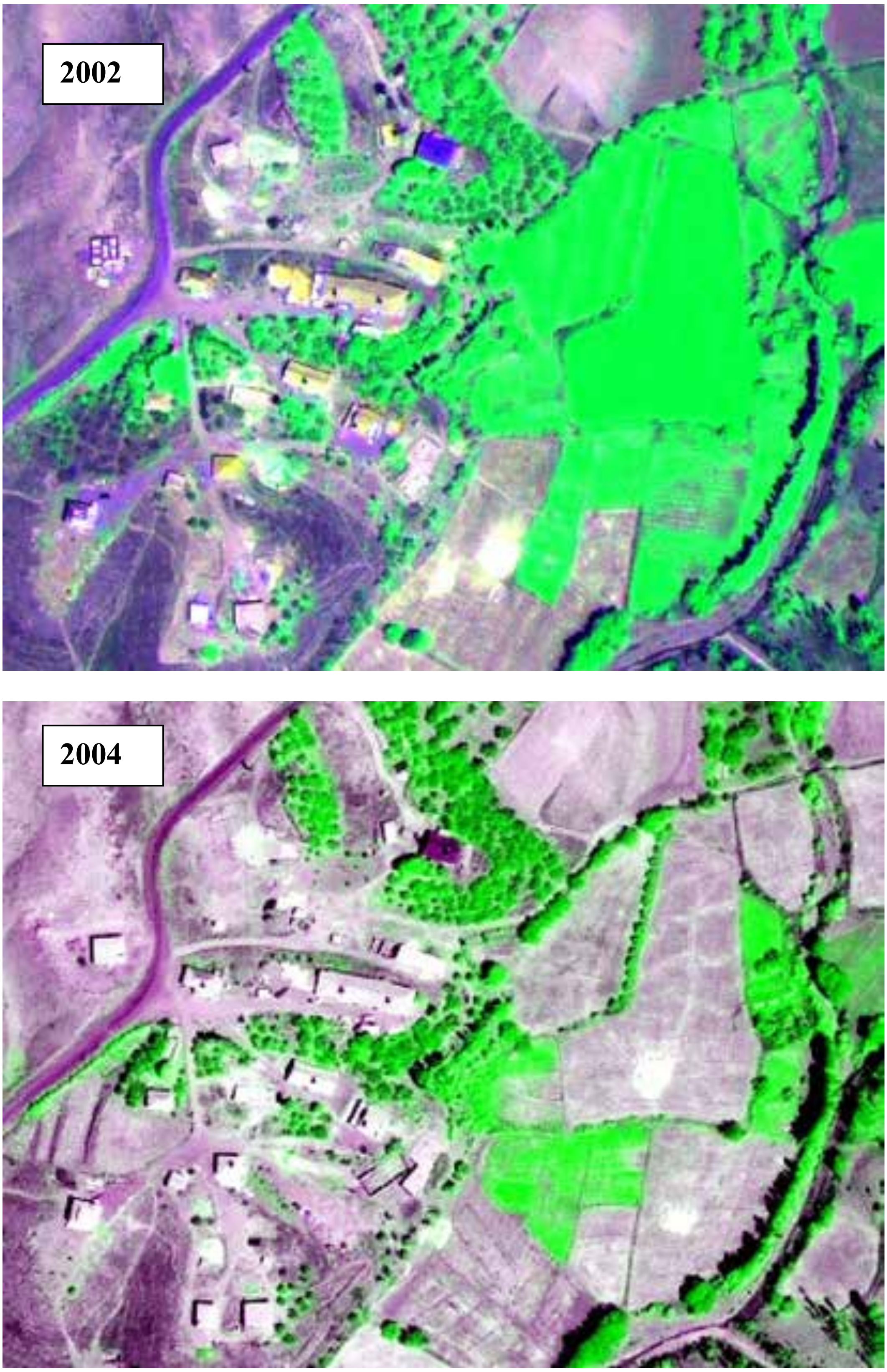


Figure 13. Sample change detection area from 2002 to 2004.

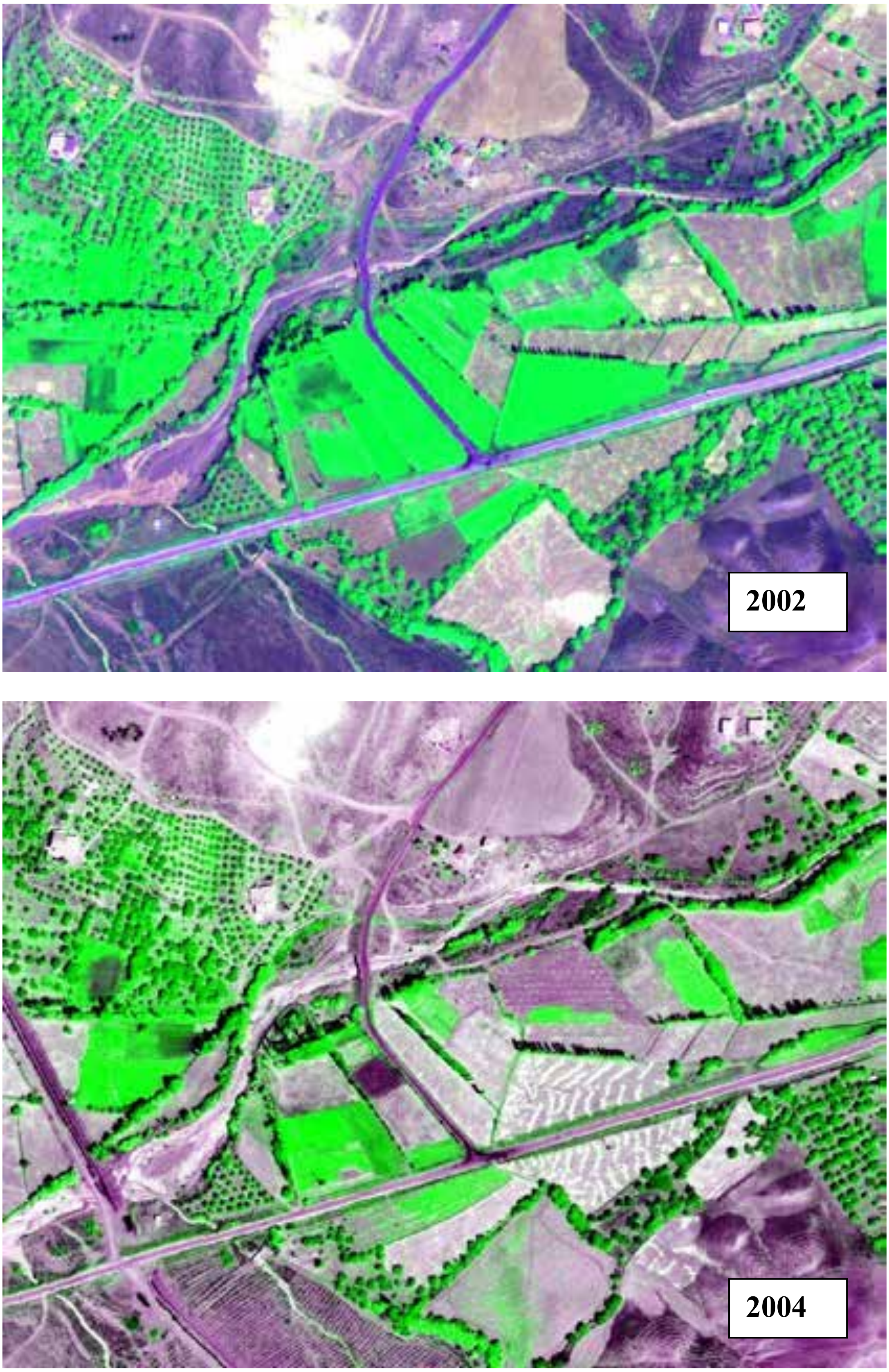


Figure 14. Sample change detection area from 2002 to 2004.

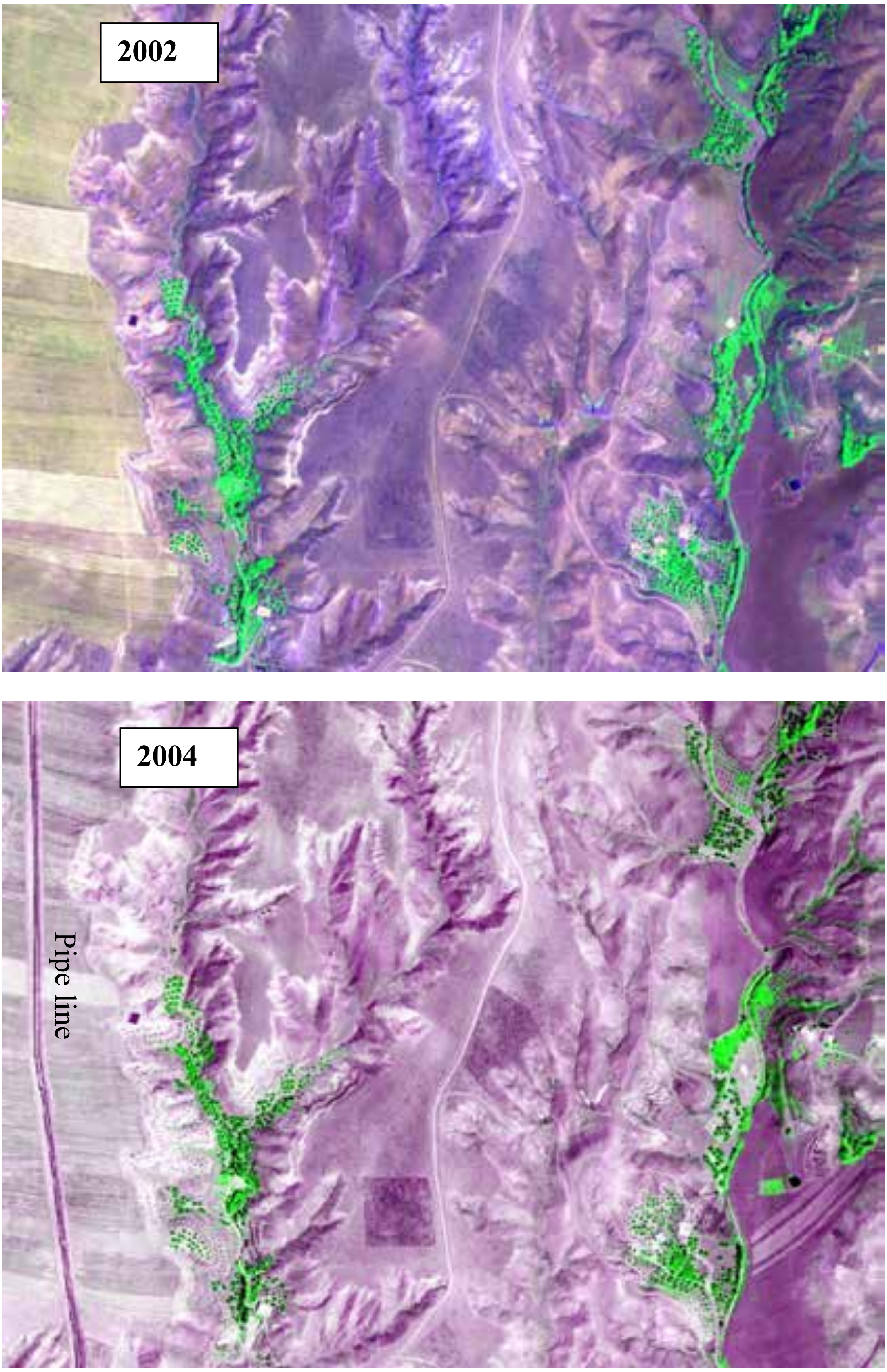


Figure 15. Sample change detection area from 2002 to 2004.

5. ANCILLIARY DATA

Topographical surface information was used for orthorectification, 3-D simulation and interpretation of the image conditions. For this purpose 1:25.000 scale vector contour data were used and produced 5 meter pixel spacing grid interval elevation model. Later aspect and slope analyses were made. DEM, Aspect and Slope classified as shown as the related figure legends. Soil vector data also can be used for interpretation and for decision support. In this study were replacing as auxiliary soil data which is prepared by Minister of Agriculture, General Directorate of Rural Services. All ancillary data are shown figures between 11 and 16.

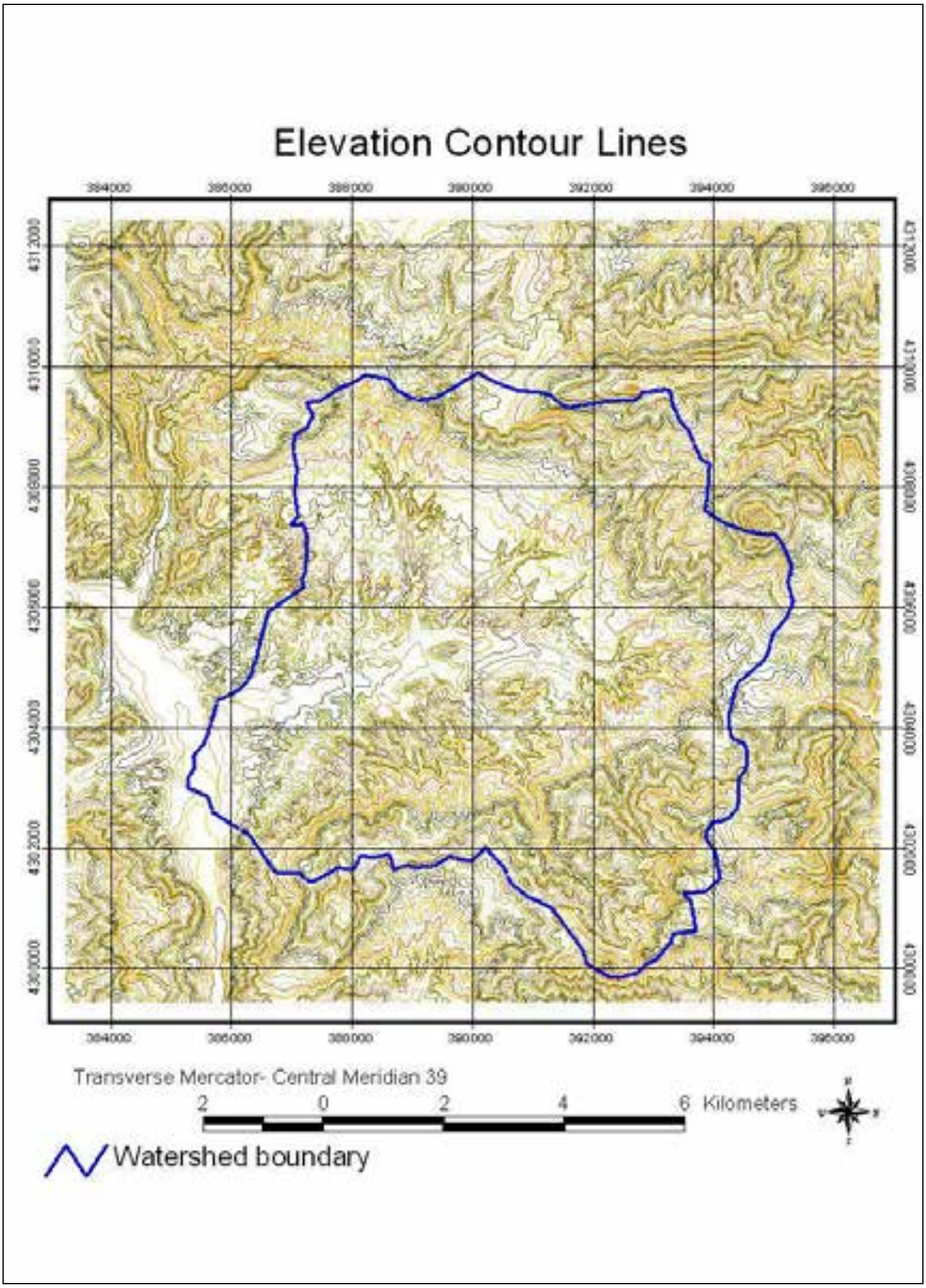


Figure 16. Vector Elevation data

7.1. Digital Elevation Model

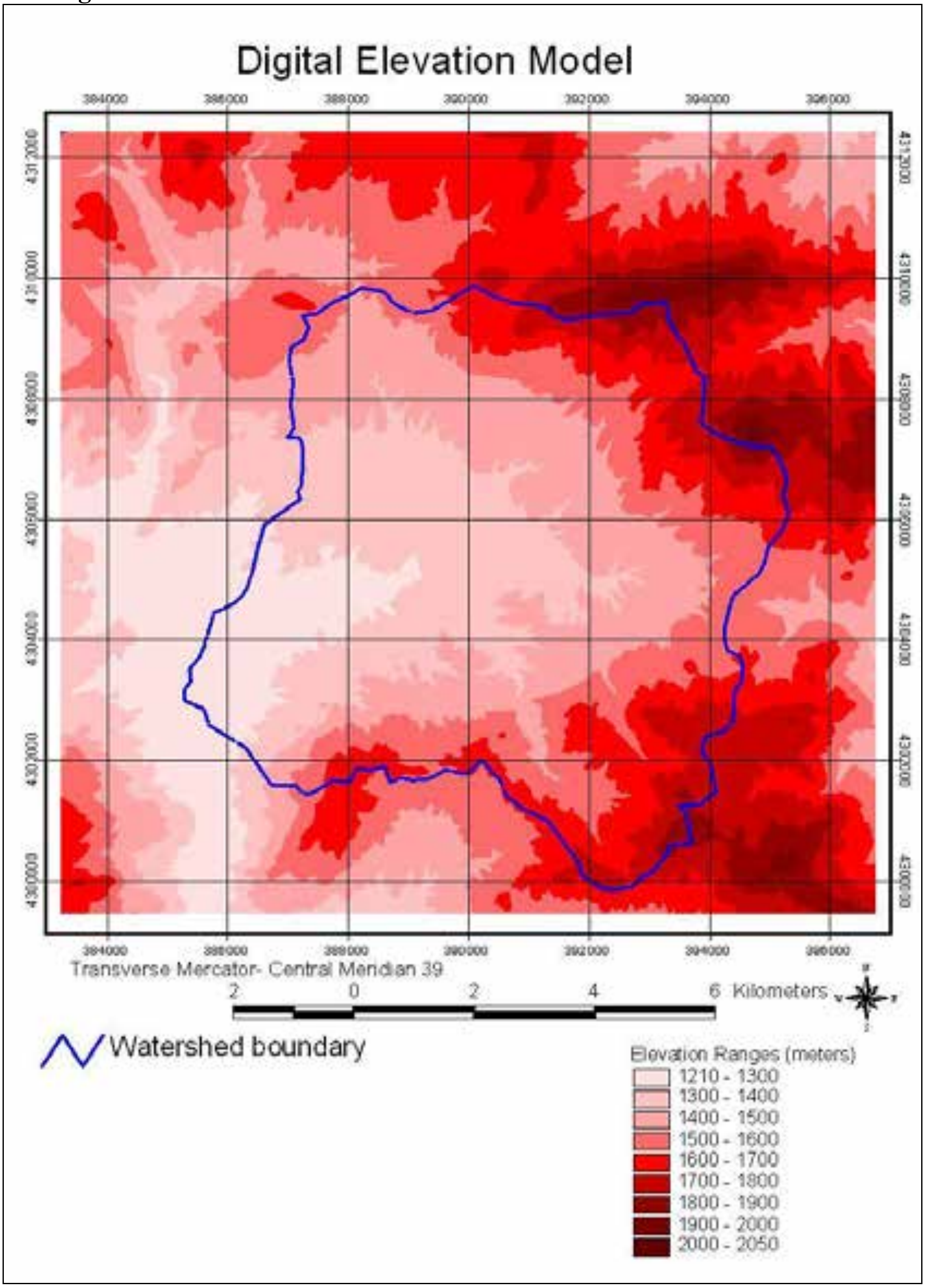


Figure 17. Digital Elevation Model

7.2. Slope Analyses

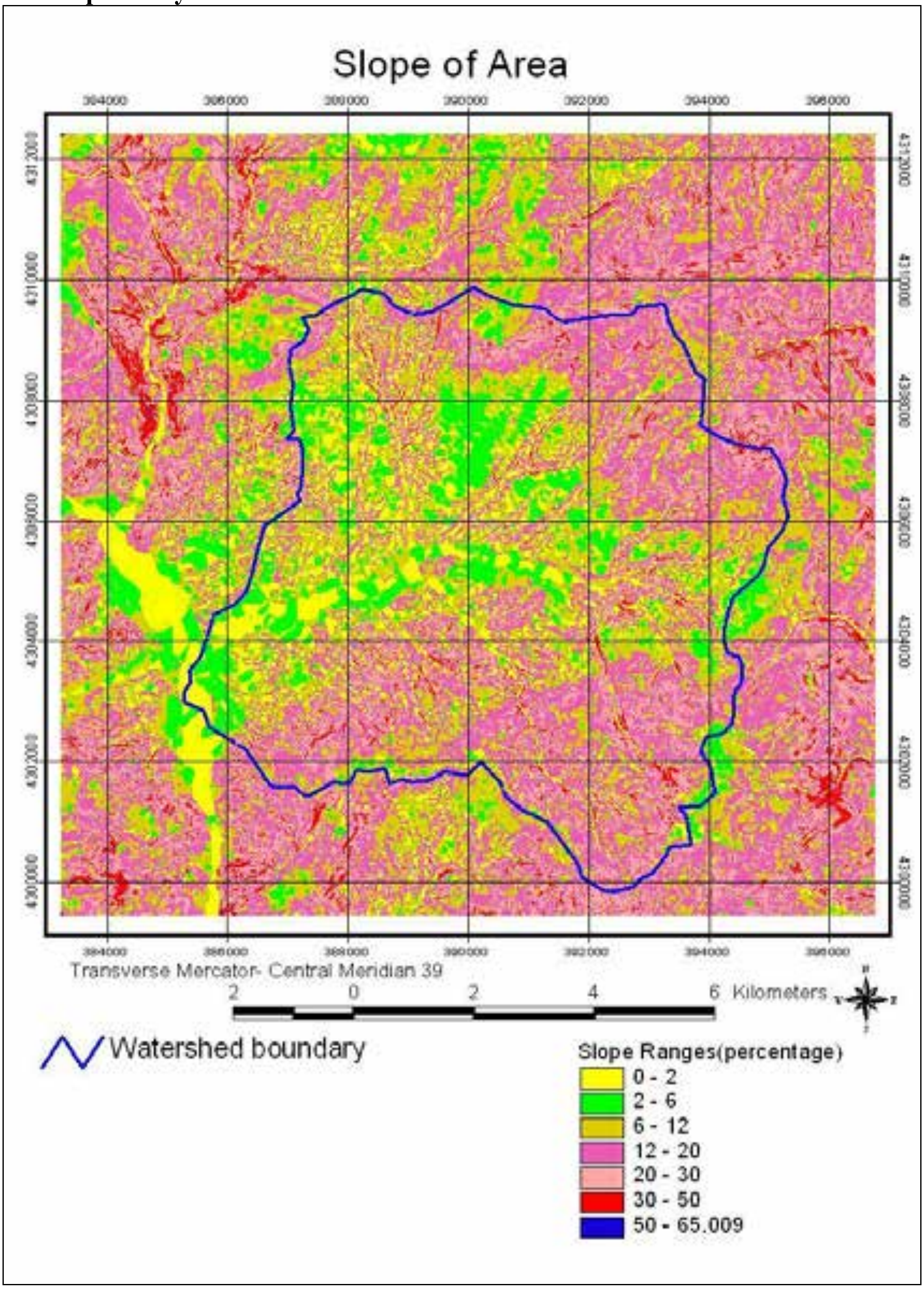


Figure 18. Slope range data

7.3. Aspect Analyses

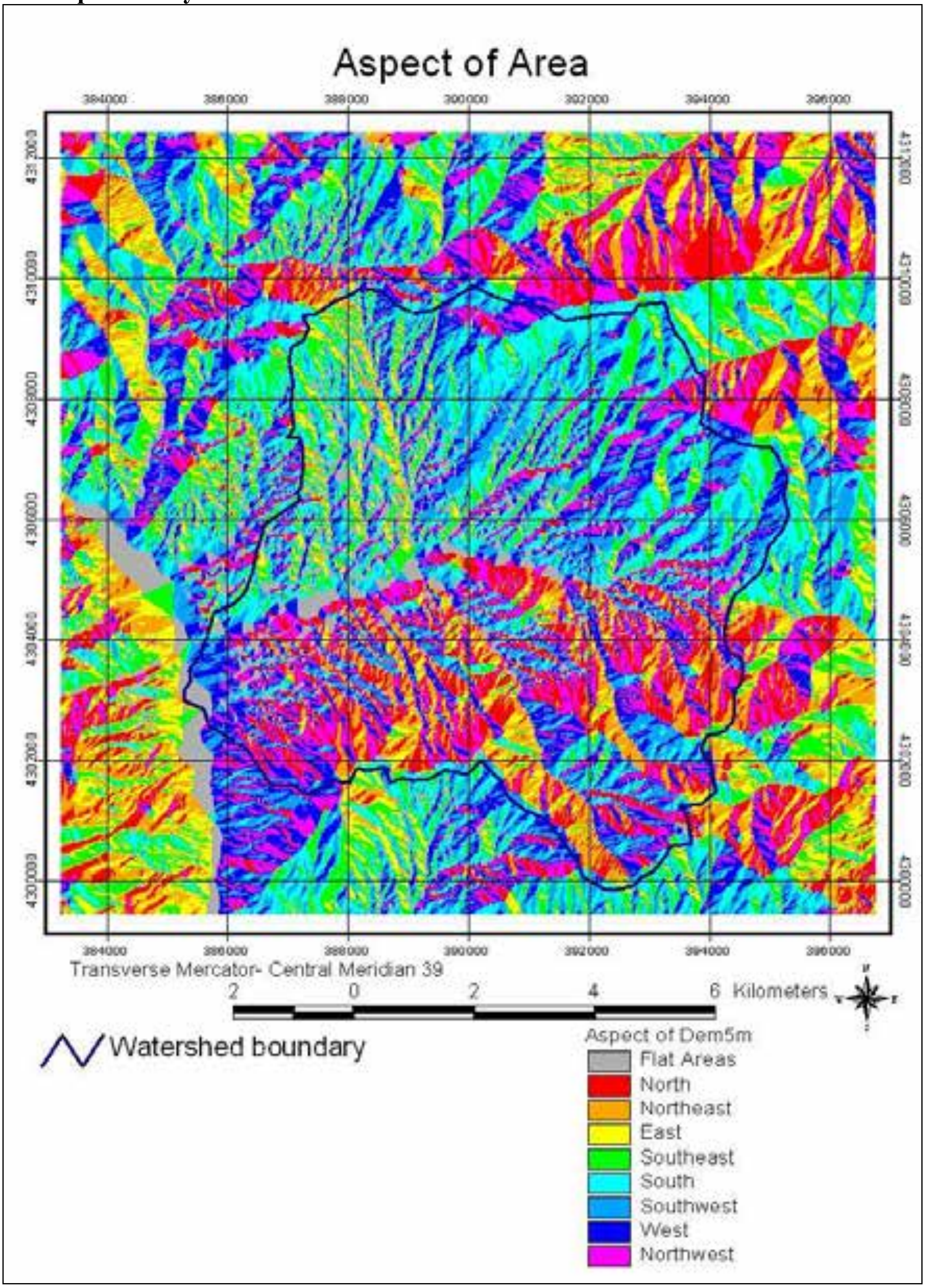


Figure 19. Aspect of area according to 8 direction and flat areas.

7.4. Soil Land Use Capability Data

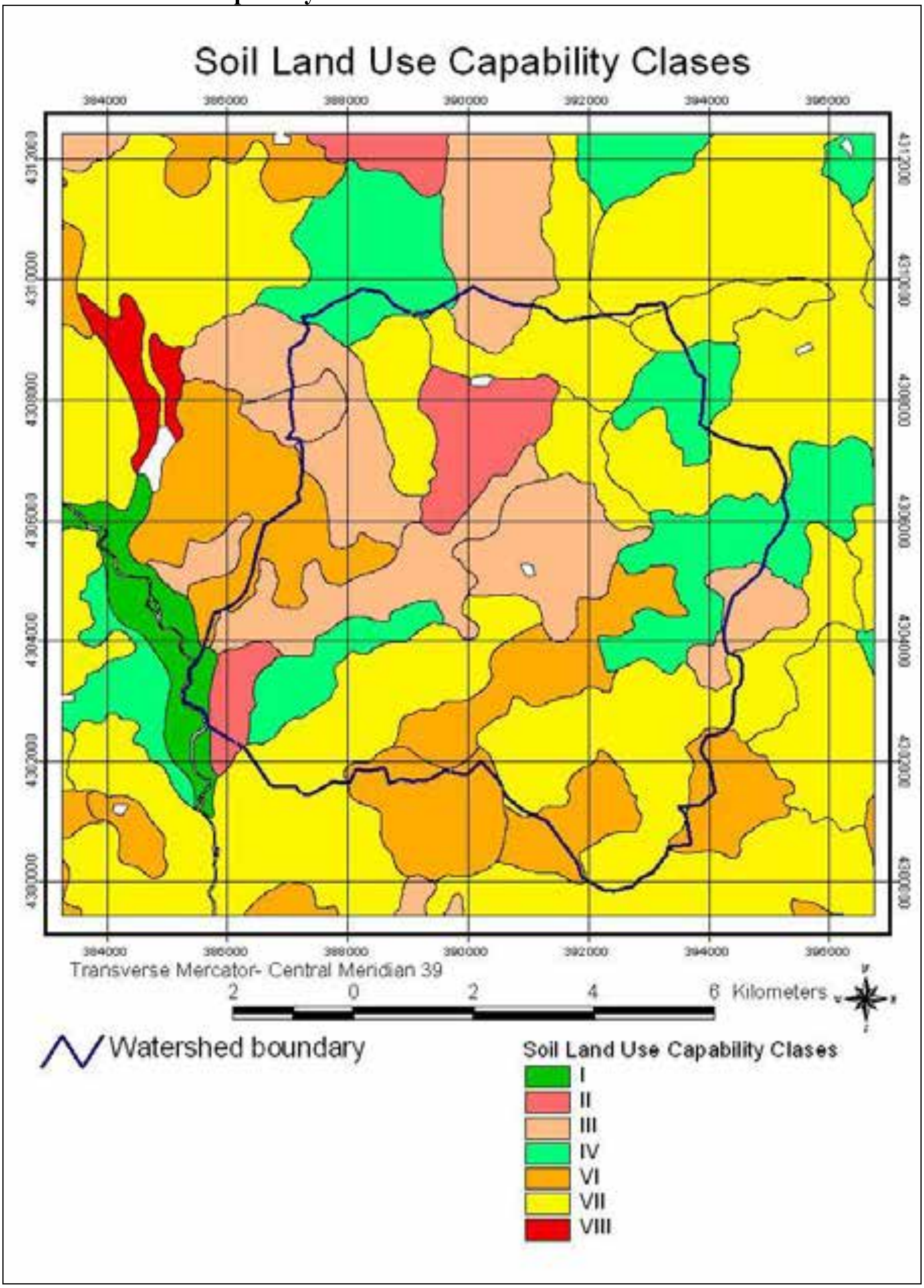


Figure 20. Soil land Use Capability Classes numbers.

7.5. Soil Dept Data

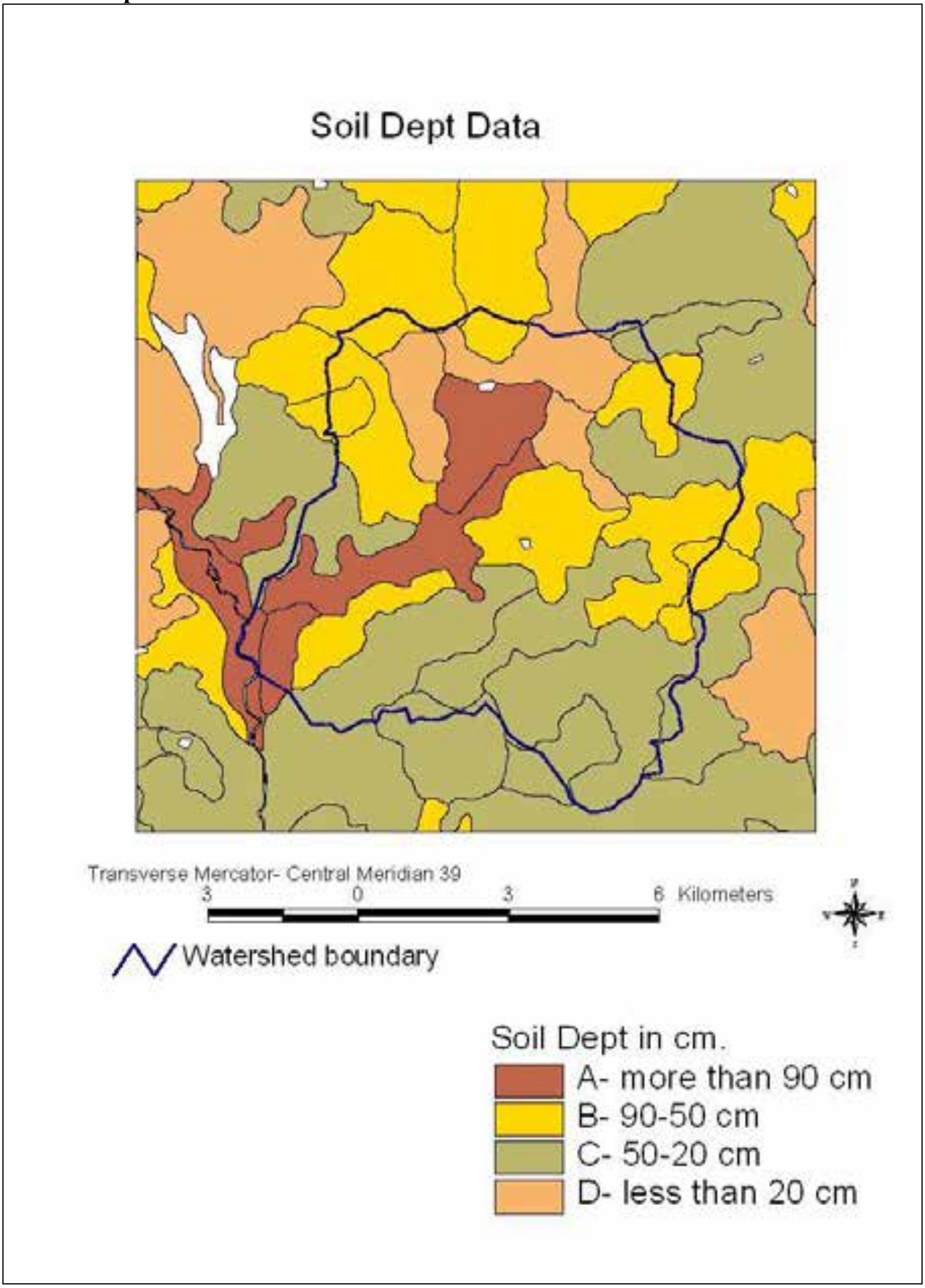
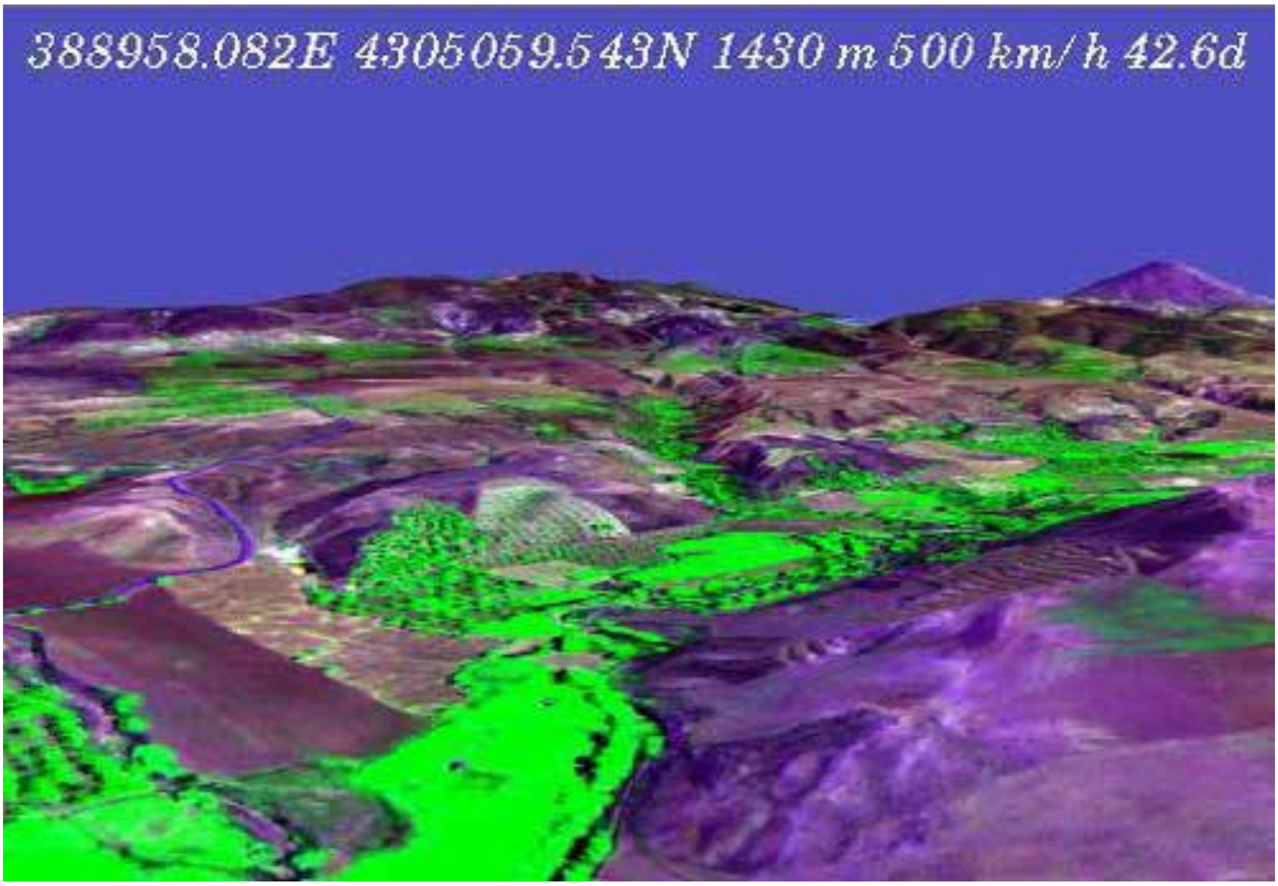
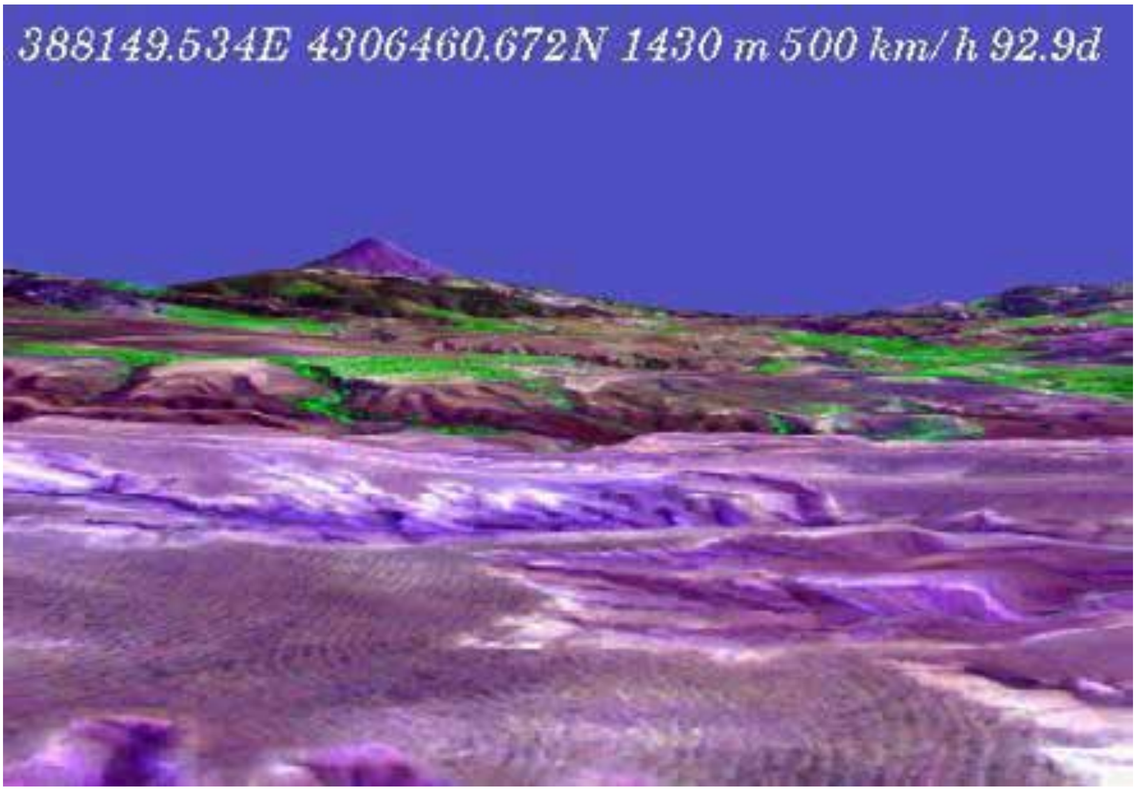


Figure 21. Soil dept data.

6. SIMULATIONS

Artificial FLY through, perspective viewing and simulations gives us too many opportunity for planning, visually interpretation and monitoring. This is more powerful supporter for decision maker. For this aim 3-Dimentional (3-D) perspective rendering FLY video and images were prepared by using digital evaluation model and orthorectified images. Some sample perspective images are shown in figure 17.





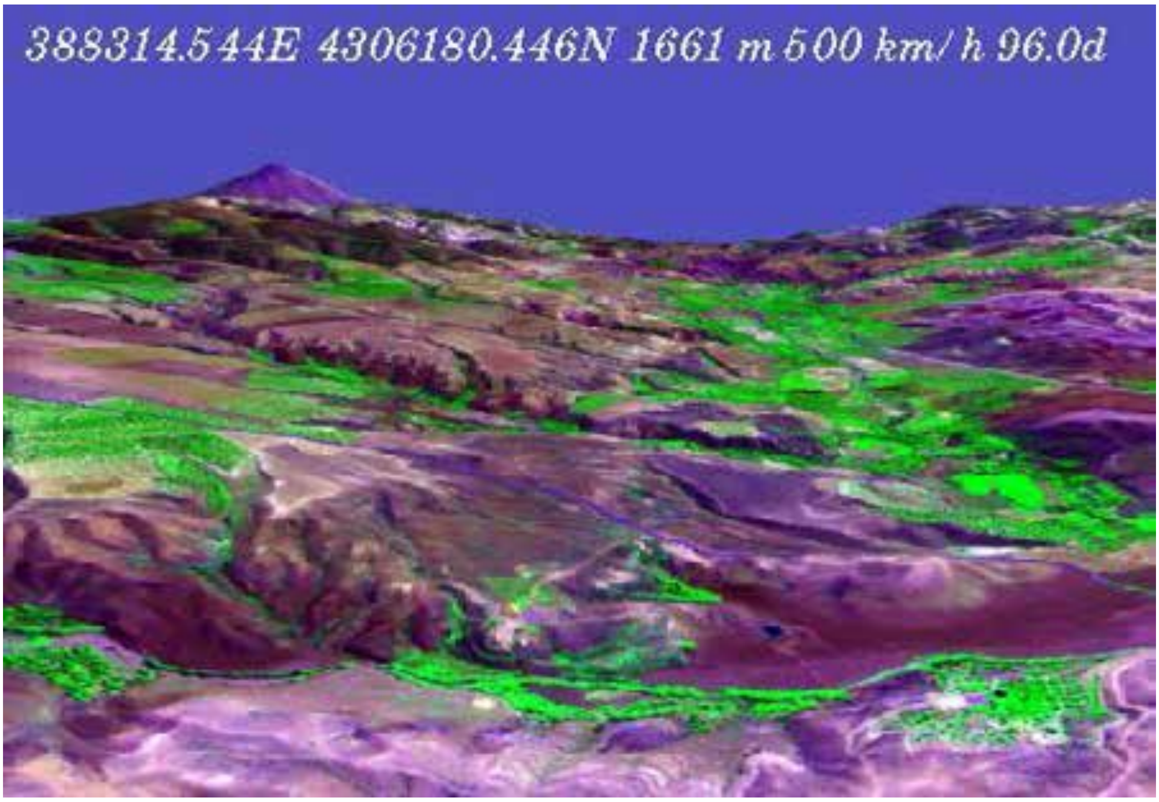


Figure 22. Sample 3-D perspective images

7. CONCLUSIONS

While working satellite data for monitoring data must be taken depend on the extraction of the desired information. In this study vegetation wants to monitor but data were taken late summers. Actually recommended date has to be in spring. So vegetation analysis can be controlled easily.

On the other hand, classification is not need working this kind of high resolution data. Because visually interpretation is better gathering for exact information. This kind of data has 11 bit data and can be identify from zero to 2048 grey level brightness. As a result of this, similar reflectance can be mixing such as range land, residue and fallow areas.

NDVI analyses are working properly. So especially for detection vegetation cover near infrared band must be supply.

As a result satellite data very useful and beneficial for determination of the land use changing. These kinds of data are time consuming and cost effectively.