Processing Remote Sensing Data Using Erdas Imagine for Mapping Aegean Sea Region, Turkey

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Research Problem

The study region is located in western Turkey, Izmir surroundings.
The region has strong anthropogenic pressure: well developed transport network, intensive shipping and maritime constructions, industrial factories, plants, densely populated urban districts, intensive agricultural cultivation.

Research Problem:

- The region of Izmir is a particular part of Turkey: it has unique landscapes with variety of vegetation types, diverse relief and natural reserve areas;
- The vegetation within the Aegean region has very complex character;
- Area is characterized by the the variety, biogeographical diversity and richness;
- At the same time, Izmir, a third large metropolis of Turkey, is an industrial city of high importance;
- Izmir is a key seaport harbor, strategic for the country and Mediterranean region;

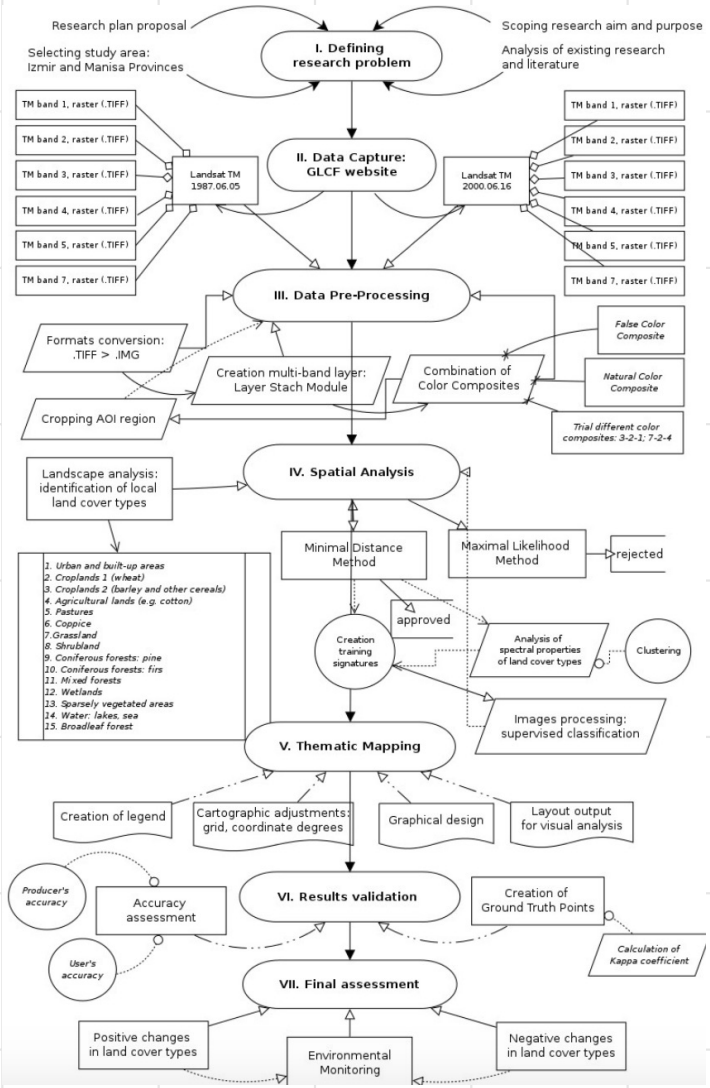
Research Questions and Goals

Western Turkey, Izmir region. Landscapes from the aerial view.
Source: Google Earth

Research Questions and Goals:

- How landscapes within the test area of Izmir region changed due to the anthropogenic effects
- Visualization of the landscapes in the given time scope of 13 years (1987-2000)
- If there are changes, what are the exact areas (in ha or km) occupied by every land cover type.
- Calculate & Assess Accuracy.
- How can remote sensing (RS) data and GIS tools of Erdas Imagine be used for answering questions (1) and (2).
- Demonstration & Discussion

Methods



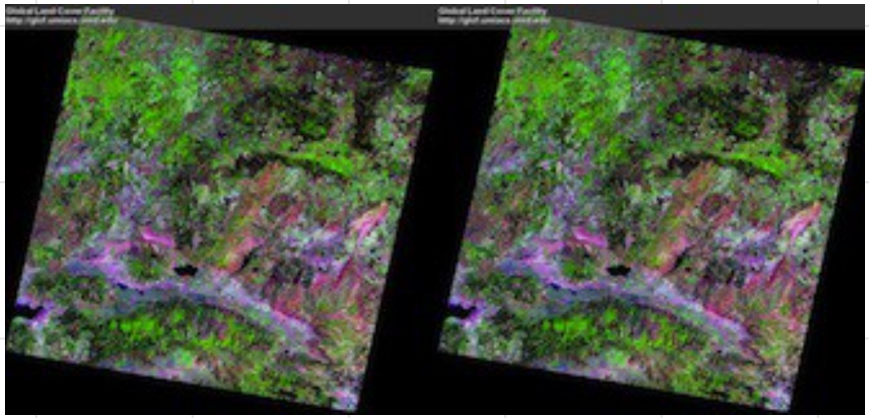
Methodological Flowchart

- Data import and conversion
- Creating multi-band layer & color composite Selecting AOI (Area Of Interest)
- Clustering segmentation and classification GIS Mapping
- Verification via Google Earth
- Accuracy Assessment
- Analyzing results

Data Import

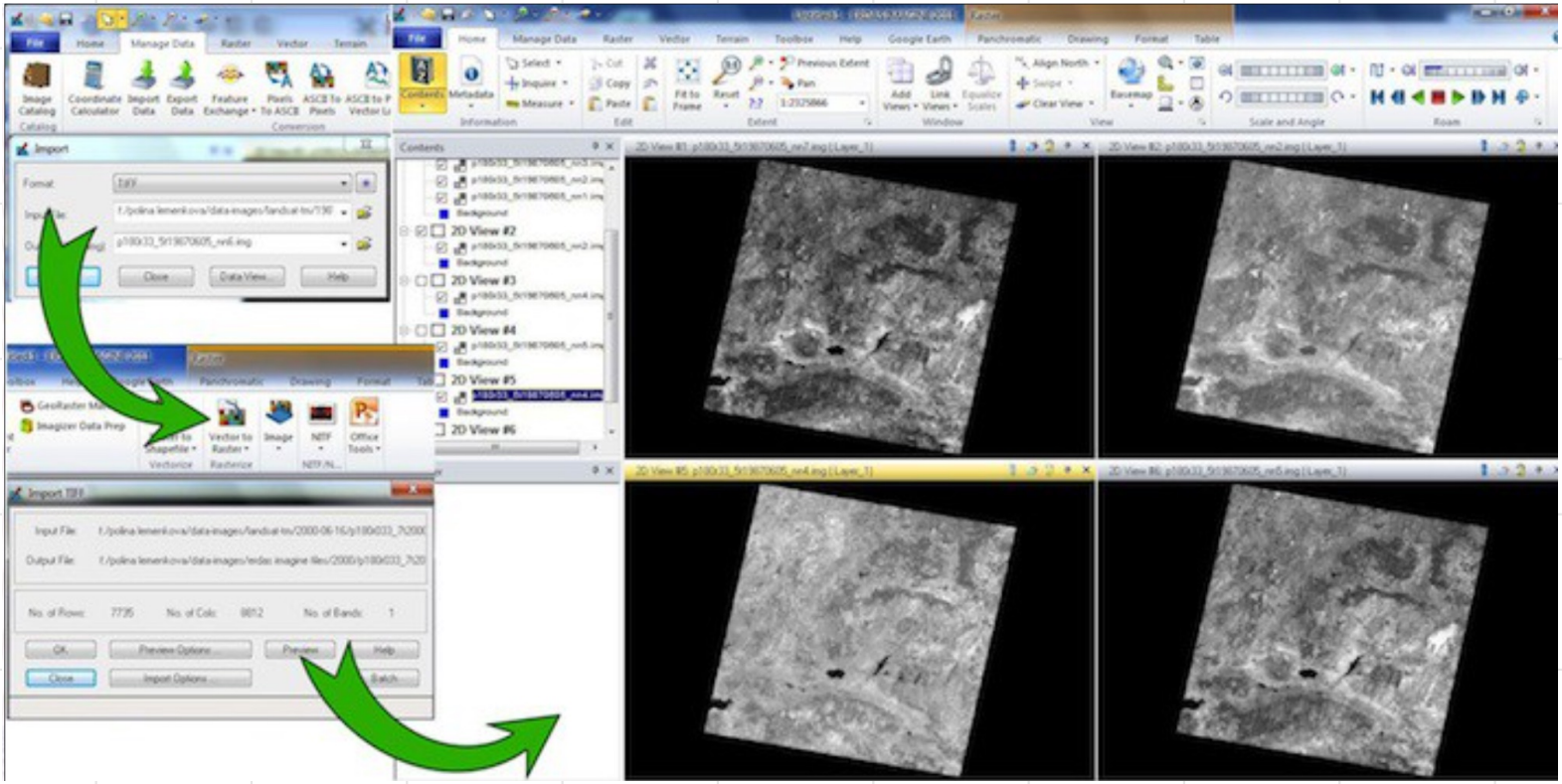
- Study Area. Selecting study area covered by Landsat TM scenes.
- GLCF website: Landsat Thematic Mapper (TM)
- Global Land Cover Facility (GLCF) Earth Science Data Interface
- Analysis of vegetation types: images taken during summer (June).

For selecting target area, a spatial mask of coordinates ranging from 26°00'-26°00' E to 38°00'-39°00' N was applied.



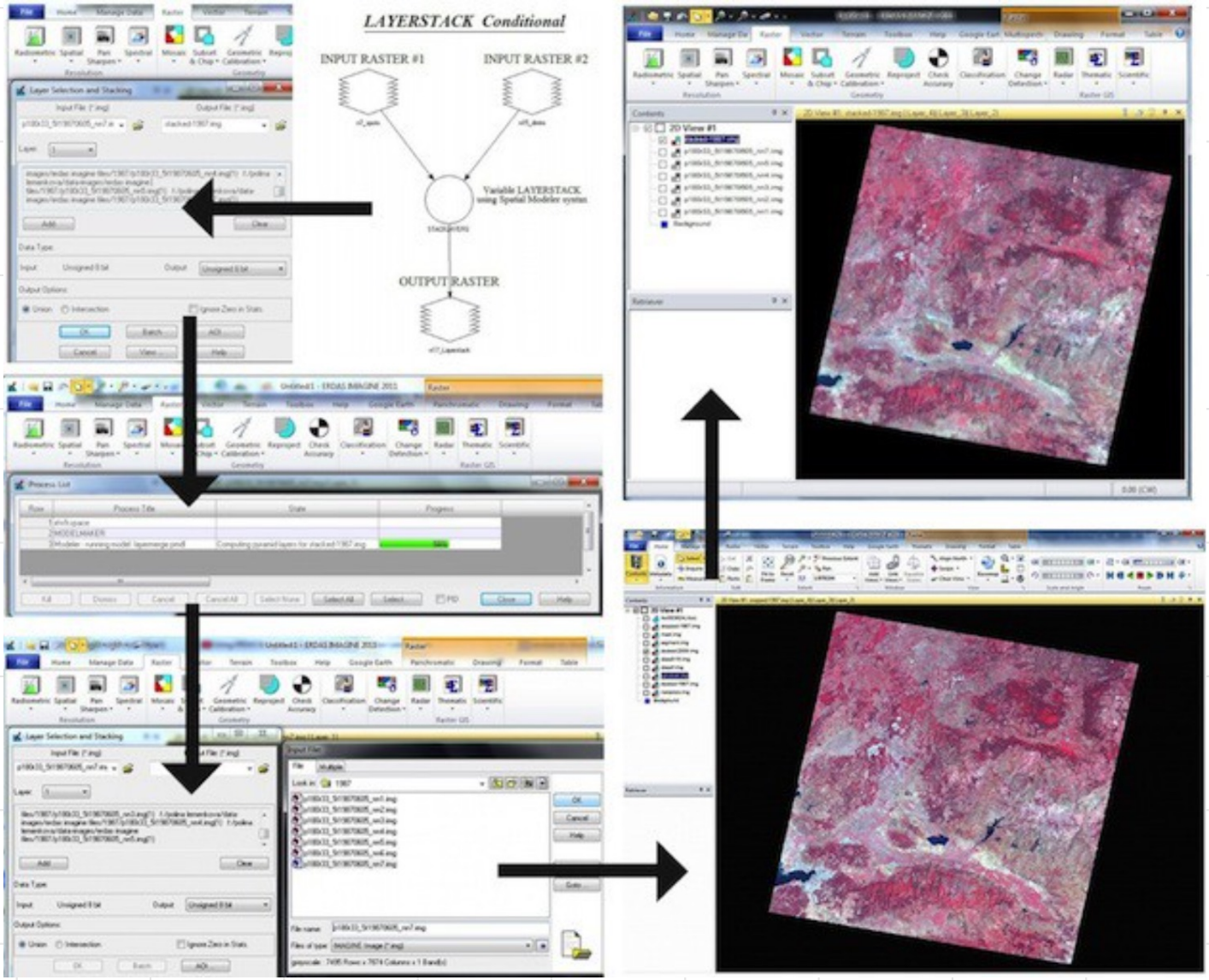
- Target images: 1987 and 2000
- Tme span of 13-years (1987-2000)
- Change detection in the land cover types.

Data Conversion



Conversion of raw .TIFF Landsat TM images into Erdas Imagine ".img" format.

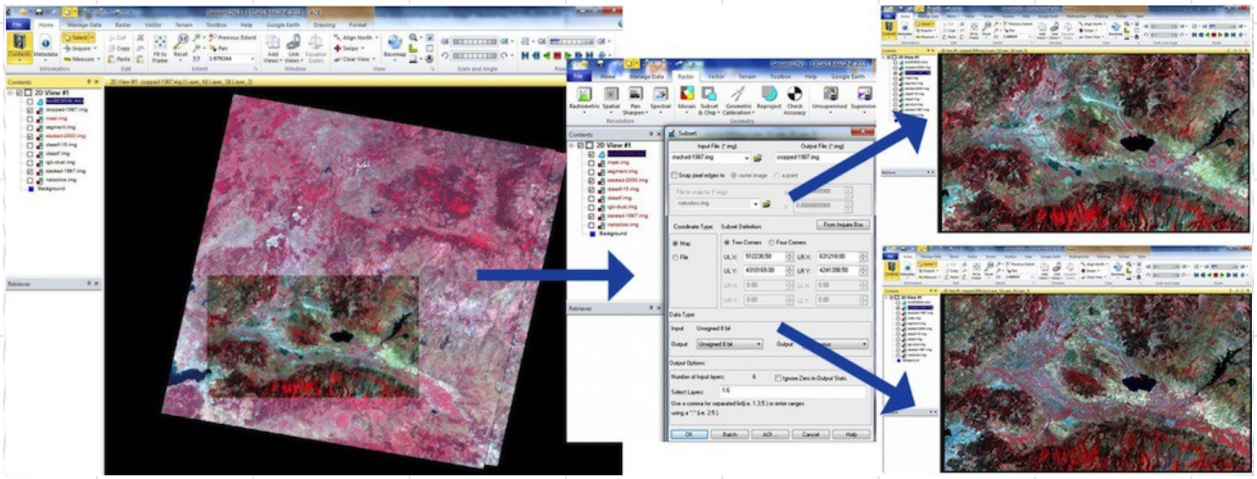
Creating Multi-band Color Composite



Selecting AOI

Test area: Izmir surroundings.

- Test area: Manisa and Izmir provinces covering various landscapes types;
- AOI ecological diversity: urban built-up areas, coastal zone, agricultural crop areas, hilly landscapes;
- Urban areas located on the coastal area of the Aegean Sea with ca. 4 M people;
- Human impact on the environment: demographic, cultural & economic pressure;
- This is reflected in various land cover types, landscapes patterns, heterogeneity;



- Left: Selecting AOI from the overlapping initial Landsat images.
- Center: adjusting parameters, Erdas Imagine.
- Right: AOI 1987 (above) and AOI 2000 (below).

Clustering Segmentation

Principle of clustering segmentation:

- The logical algorithmic approach of clustering segmentation consists in merging pixels on the images into clusters.
- Grouping pixels is based on the assessment of their homogeneity, that is, distinguishability from the neighboring pixel elements.
- Clusters enable to analyze spectral & textural characteristics of the land cover types, i.e. to perform spatial analysis.
- Accurate cluster segmentation of the images is an important step for supervised classification.

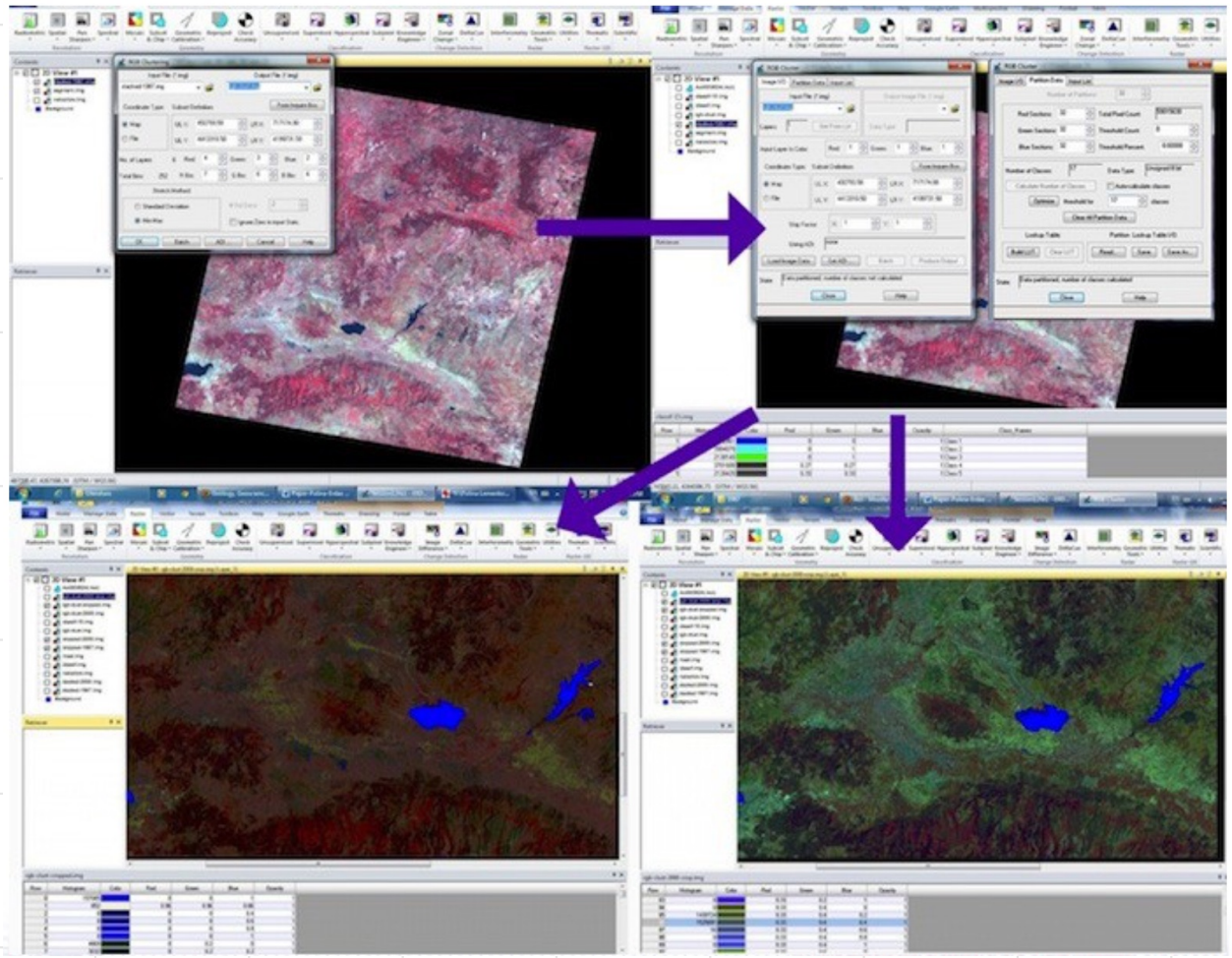
Differentiating Patterns via DNs:

- Image classification consists in assignation of all pixels into land cover classes of the study area.
- Classification is done using multispectral data, spectral pattern (signatures) of the pixels that represent land cover classes.
- Various land cover types and landscape features are detected using individual properties of digital umbers (DNs) of the pixels.
- The DNs show values of the spectral reflectance of the land cover features, and individual properties of the objects.

Clustering: Algorithm

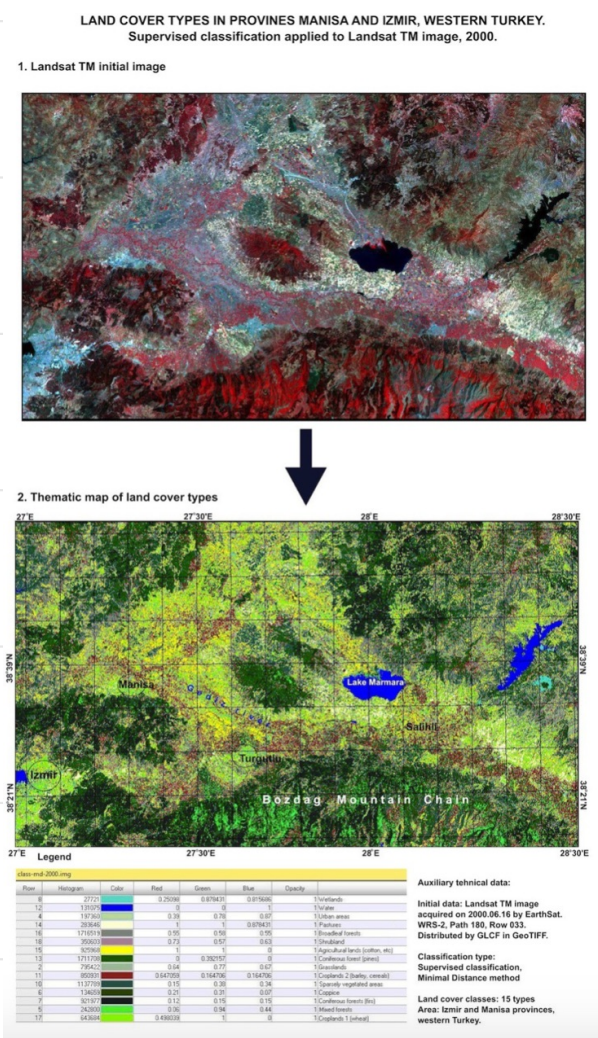
- Clustering was performed to classify pixels into thematic groups, or clusters.
- Number of clusters = 15, which responds to the selected land cover types in the study area.
- During clustering, each digital pixel on the image is categorized to the respecting cluster,
- Assigned cluster is the one to which the mean DN value of the given pixel is the closest.
- The process is repeated in an iterative way,
- Iteration continued until optimal values of the class groups and the pixels assigned to the corresponding classes are reached.
- Afterwards, the land cover types were visually assessed and identified for each land cover class.

Clustering: Visualization

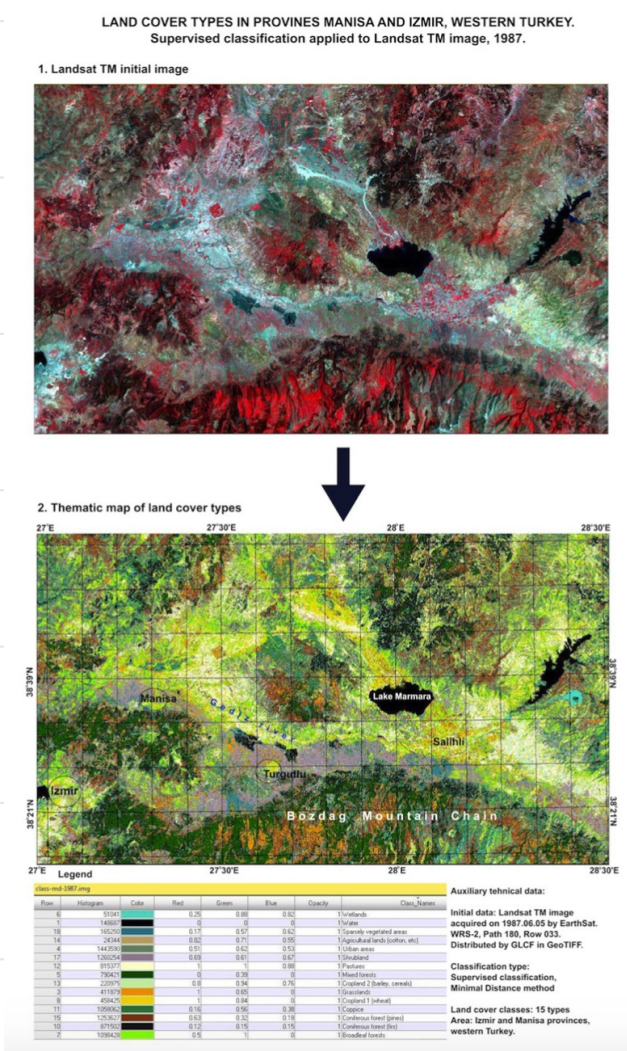


- Final thematic mapping is based on the results of the image classification:
- Visualizing landscape structure and land cover in the study area.
- Final thematic maps are represented on the following two slides.

Maps of 1987 and 2000



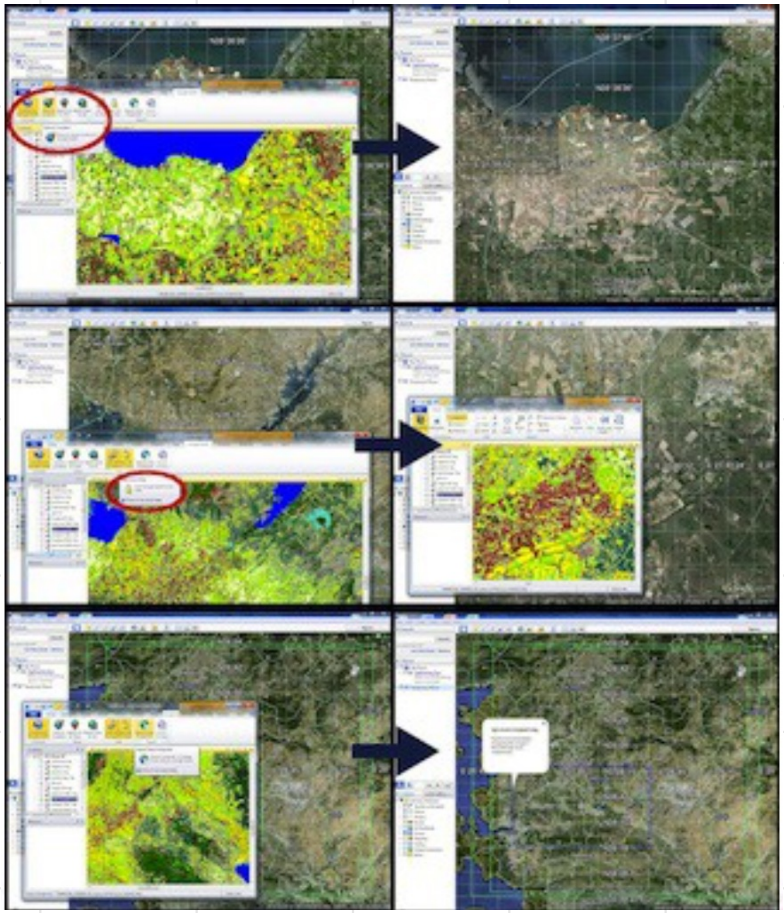
1987



2000

Classified Landsat TM image (above) and thematic map of land cover types (below).

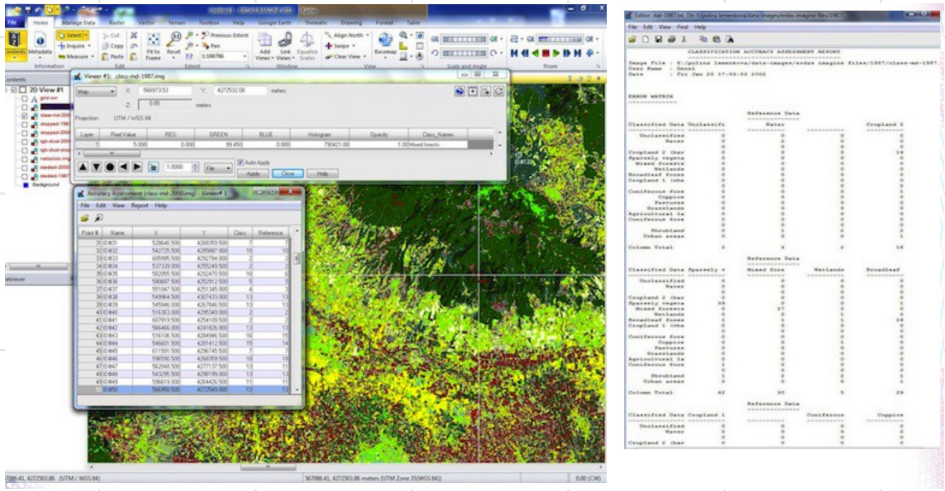
Verification via the Google Earth: Algorithm



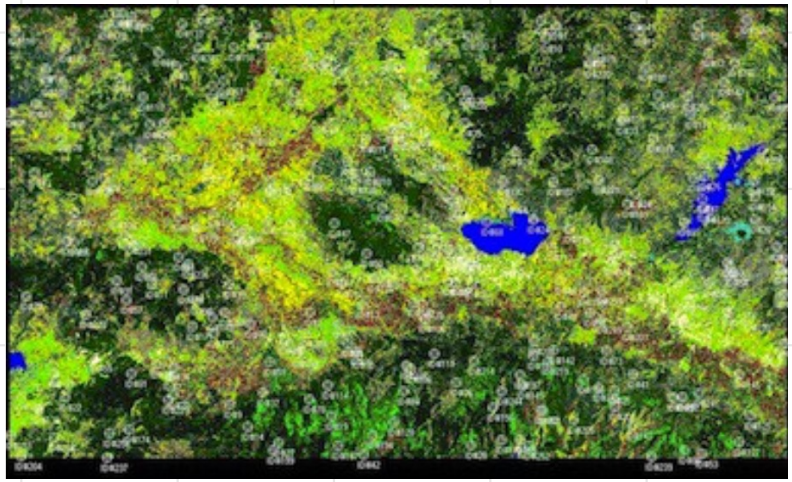
Linking Map with the Google Earth

- The selected areas with the most diverse landscape structure and high heterogeneity of the land cover types, have been verified by the overlapping of the Google Earth aerial images.
- The function "connect to Google Earth" was activated that enabled to visualize the same region of the current study on the Google Earth in a simultaneous way.
- The functions "Link Google Earth to View" and "Sync Google Earth to View" enabled to synchronize the view areas between the Google Earth and the current view on the image.
- This enabled to check the difficult study areas where questions arose in which land cover type this site belongs.

Computing Error Matrix



Left: Correction of the assigned class values of the generated points according to the real values.
Right: Error matrix generated for each land cover class, Landsat TM classification 1987.



Results validation: the quality control and validation of the results
Quality control was performed using accuracy assessment operations in Erdas Imagine menu

Final Calculations

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
Water	3	2	2	66.67%	100.00%
	2	0	0	---	---
Cropland 2 (bar	18	14	14	77.78%	100.00%
Sparsely vegeta	42	41	39	92.86%	95.12%
Mixed forests	30	27	27	90.00%	100.00%
Wetlands	5	1	1	20.00%	100.00%
Broadleaf fores	29	31	26	89.66%	83.87%
Cropland 1 (whe	9	5	5	55.56%	100.00%
	4	0	0	---	---
Coniferous fore	21	23	19	90.48%	82.61%
Coppice	25	23	21	84.00%	91.30%
Pastures	21	18	18	85.71%	100.00%
Grasslands	6	2	2	33.33%	100.00%
Agricultural la	5	2	2	40.00%	100.00%
Coniferous fore	34	34	31	91.18%	91.18%
	1	0	0	---	---
Shrubland	1	28	1	100.00%	3.57%
Urban areas	0	5	0	---	---
Totals	256	256	208		

Overall Classification Accuracy = 81.25%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7923

Conditional Kappa for each Category.

Class Name	Kappa
Unclassified	0.0000
Water	1.0000
	0.0000
Cropland 2 (barley, cereals)	1.0000
Sparsely vegetated areas	0.9416
Mixed forests	1.0000
Wetlands	1.0000
Broadleaf forests	0.8181
Cropland 1 (wheat)	1.0000
	0.0000
Coniferous forest (firs)	0.8105
Coppice	0.9036
Pastures	1.0000
Grasslands	1.0000
Agricultural lands (cotton, etc)	1.0000
Coniferous forest (pines)	0.8983
	0.0000
Shrubland	0.0319
Urban areas	0.0000

----- End of Kappa Statistics -----

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
	3	0	0	---	---
Grasslands	23	25	20	86.96%	80.00%
	5	0	0	---	---
Urban areas	9	8	7	77.78%	87.50%
Coniferous fore	10	13	9	90.00%	69.23%
Coppice	4	3	3	75.00%	100.00%
Coniferous fore	23	19	18	78.26%	94.74%
Wetlands	3	1	0	0.00%	0.00%
	6	0	0	---	---
Croplands 1 (wh	25	30	24	96.00%	80.00%
Croplands 2 (ba	17	17	14	82.35%	82.35%
Water	7	6	4	57.14%	66.67%
Mixed forests	32	41	31	96.88%	75.61%
Agricultural la	16	10	10	62.50%	100.00%
Pastures	18	19	14	77.78%	73.68%
Sparsely vegeta	42	46	40	95.24%	86.96%
Broadleaf fores	10	14	9	90.00%	64.29%
Shrubland	3	4	3	100.00%	75.00%
Totals	256	256	206		

Overall Classification Accuracy = 80.47%

----- End of Accuracy Totals -----

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7843

Conditional Kappa for each Category.

Class Name	Kappa
Unclassified	0.0000
	0.0000
Grasslands	0.7803
	0.0000
Urban areas	0.8704
Coniferous forest (pines)	0.6798
Coppice	1.0000
Coniferous forests (firs)	0.9422
Wetlands	0.0119
	0.0000
Croplands 1 (wheat)	0.7784
Croplands 2 (barley, cereals)	0.8110
Water	0.6579
Mixed forests	0.7213
Agricultural lands (cotton, etc)	1.0000
Pastures	0.7169
Sparsely vegetated areas	0.8440
Broadleaf forests	0.6283
Shrubland	0.7470

----- End of Kappa Statistics -----

Classification of Landsat TM image, 1987. Classification of Landsat TM image, 2000.

Accuracy Results: Kappa Statistics

Land Cover Class	No pixels, 1987	No of pixels, 2000	Area(ha), 1987	Area (ha), 2000
Grasslands	411879	795422	2141	4134
Urban areas	1443590	1797360	7504	9342
Coniferous forest (pines)	1253627	1711708	6516	8898
Coniferous forests (firs)	871502	921977	4530	4793
Coppice	1058062	134659	5500	700
Wetlands	51041	27721	265	144
Croplands 1 (wheat)	458425	643684	2382	3345
Croplands 2 (barley, cereals)	220975	850931	1149	4423
Mixed forests	790421	242800	4109	1262
Agricultural lands (cotton, etc)	24344	925968	127	4813
Pastures	815377	283646	4238	1474
Sparsely vegetated areas	165250	1137789	859	5914
Broadleaf forests	1716519	1098428	8923	5710
Shrubland	1260254	350603	6550	1822

Accuracy results for Landsat TM image classification are computed as follows:

- The classification of the image 1987: accuracy 81.25%, 2000: 80,47%.
- Kappa statistics for the image 2000: 0.7843, for the image 1987: 0.7923

Comments on Table

- The results indicate changes in land cover types affected by human activities, i.e. increased agricultural areas.
- 1987: croplands (wheat) covered 71% of the today's area (2000): 2382 vs. 3345 ha.
- Increase in barley cropland areas is noticeable as well: 1149 ha in 1987 vs. 4423 ha in 2000.
- Sparsely vegetated areas now also occupy more areas : 5914 ha in 2000 against 859 ha in 1987.
- Natural vegetation, decreased, which can be explained by the expansion of the agricultural lands.
- 1987: coppice areas covered 5500 ha while later on there are only 700 ha in this land type.

Conclusions

Conclusions:

- Increased human activities (agricultural works, urbanization, industrialization) affect environment, cause negative impacts on the ecosystems and make changes in the vegetation coverage (land cover types).
- Climate change affect land cover types: decrease of typical woody vegetation.
- Drastic land use changes are recorded and detected in diverse regions of Turkey, including Izmir surroundings.

Résumé:

- Monitoring land cover changes is necessary for maintaining environmental sustainability.
- Updated information and spatial analysis are useful tools.
- The presentation demonstrated how landscapes changed in the selected study area at a 13-year time span (1987-2000).
- The data included Landsat imagery covering research area. The image processing was done by classification methods.
- The classification results detected changes in landscapes in 2000 comparing to 1987. This proved anthropogenic impacts on the landscapes which affect sustainable environmental development of the region.
- The results demonstrated successful combination of the RS data and methods of GIS spatial analysis, effective for monitoring of highly heterogeneous landscapes in the area of intensive anthropogenic activities.

Thanks

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