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Geospatial technology for land cover analysis

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The Izmir region in Turkey is extremely valuable for the environment while being used immensely for tourism, agriculture and recreation. The geographic area of western Turkey is known for its unique physical and environmental settings. Due to its location in the Mediterranean climate, the region has certain typical features and is influenced by the local and regional climatic setting. The geography of the region combines diverse landforms, various geomorphological features, natural landscapes, species and vegetation richness: mountainous and hilly landscapes, caves, islands in the coastal area and lakes. The geology of the area of Western Anatolia is characterized by the neotectonic active faulting and high seismicity, which leads to the geomorphic instabilities and landslide formation in the research area. The vegetation in the study area is dominated by typical Mediterranean flora.



Fig: Study area within Turkey (Map modified by authors from Britannica Encyclopedia)

The current environmental situation within the terrestrial parts of the ecosystems has been well discussed in several works. The main issues concerning deforestation of precious forest communities are desertification, soils erosion and land degradation in the surroundings. For example, plant cover and land degradation on Karaburun Peninsula has been studied and detected by *Nurlu et al. (2003)* in their remote sensing based research. Karaburun Peninsula is an important part of Aegean Sea ecosystems and is well known in Turkey as one of the major undisturbed sites in western Turkey with precious biodiversity structure, aesthetic landscapes and unique environment. To maintain sustainable development of the Turkish nature, the unique landscapes should be protected for the sustainable co-existence of man and nature.

Other sources of environmental threats are radioactive wastes and radionuclides that originate both from natural sources, for instance leaching from minerals, and from pollutant sources, mostly from nuclear power plants, explosions and accidents. These factors of ecological contamination have direct impact on the terrestrial ecosystems.

The data used in the article consists of the following types:

Landsat TM Image from the EarthSat producer, WRS-2, Path 180, Row 033, acquired on 1987.06.05, distributed by GLCF in GeoTIFF format.

Landsat ETM+ image from the USGS producer, WRS-2, Path 180, Row 033 acquired on 2000.06.16, distributed by GLCF in GeoTIFF format.

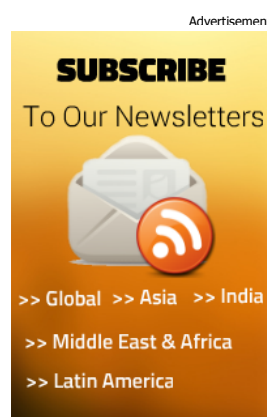
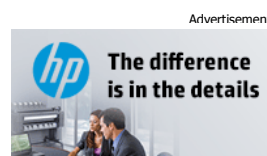
Spatial analysis

Development of spectral signatures for land cover classes

The classification of Landsat TM imagery for the same study area taken at different years allowed the recording of gradual land degradation. The last one is mainly caused by intensive construction of the second house summer cottages, and tourist activities. Recent changes in land use / land cover types in selected regions of Turkey have been proved by *Evrindik et al. (2011)* who performed historical land use change detection using measurements of carbon that indirectly indicate the extent of peatlands within the landscapes. The use of the Landsat TM images was applied to assess changes in the land cover types over time.

The thematic mapping of the land cover types in the selected area has been done using methods of supervised classification. The legend representing land cover classes include a variety of land types that exist in the Izmir surroundings. After determining the land cover characteristics, separating images into diverse homogeneous areas, a compilation of the following land cover type parameters was done:

- Urban areas: residential and built-up regions, roads; 2) Croplands-1 (wheat); 3) Croplands-2 (barley and other cereals); 4) Agricultural lands (e.g. cotton); 5) Pastures; 6) Grassland; 7) Shrubland; 8) Broadleaf forest; 9) Evergreen needleleaf forest, pine (*Pinus brutia*, *P.nigra*, *P.pinea*, *P.silvestris*); 10) Evergreen coniferous forests, firs (*Abies*); 11) Mixed forests; 12)



Wetlands; 13) Sparsely vegetated areas; 14) Water bodies (natural and artificial lakes, rivers); 15) Coppice

Training sites were digitised as areas of known land cover type identity. The creation of training polygons was performed using manual digitising available in 'Drawing' function of Erdas Imagine, by specifying the corner points of each polygon. The attributive characteristics on the areas were entered using appropriate columns with 'land cover types'. In such a way, specific training areas were identified for each, from the 15 land use classes. The land cover classes were identified as sets of pixels that best represent each land type and region according to their spectral characteristics and topological information: location, neighborhood, type and size of the polygons, etc.

Histogram	R	G	B	Opacity	Name of the Land Use Class
795422	0.64	0.77	0.67	1	Grasslands
197360	0.39	0.78	0.87	1	Urban areas
242800	0.06	0.94	0.44	1	Coniferous forest (pines)
134659	0.21	0.31	0.07	1	Coppice
921977	0	0.39	0	1	Coniferous forests (firs)
27721	0	0.18	0.14	1	Wetlands
1137789	0.82	0.71	0.55	1	Croplands 1 (wheat)
850931	0.63	0.13	0.94	1	Croplands 2 (barley, cereals)
131075	0	0.07	0.17	1	Water
1711708	0.47	0.22	0.27	1	Mixed forests
283646	1	0.84	0	1	Agricultural lands (cotton, etc)
925968	0.68	0.75	0.96	1	Pastures
1716519	0.55	0.58	0.55	1	Sparsely vegetated areas
643684	0.960784	0.960784	0.862745	1	Broadleaf forests
350603	0.73	0.57	0.63	1	Shrubland

Table: Statistics on spectral characteristics of the land cover classes, as classified on Landsat TM image 2000

Supervised classification: Minimal Distance and Maximal Likelihood approaches

The traditional methods of classification can roughly be divided into two approaches: unsupervised and supervised. The current study was done using supervised methods, since it better corresponds to the target task. The unsupervised approach categorises pixels into spectral groups that may be mixed with other lands cover types, or do not clearly specify as to which class group do they belong to. Supervised classification enables much more user control on the process.

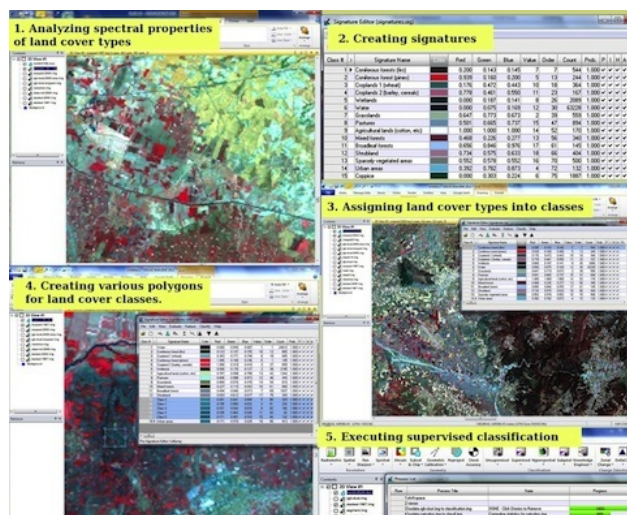


Fig.3. The process of signature creation, fragment, 1987

During supervised classification, the pixel classification process is carefully supervised by the user, via creation of training polygons and then assigning of pixels into these groups by the specific algorithm approach.

There are different methods of the supervised classification, which depend on the mathematic approaches of the computer GIS program that uses a specific algorithm procedure for the image classification.



Fig: Fragments of classified Landsat TM 2000 image (full AOI area), illustrating two classification methods: 'Maximal Likelihood' (left) and 'Minimal Distance' (right)

For instance, the most well-known are Parallelepiped classification, Neural Nets, Decision Trees, Mahalanobis Distance, Minimum Distance, and Maximum Likelihood classifiers. Usually, it is not easy to decide, which classifier method is the best

for actual research problem, due to different factors such as characteristics of the images, mapping scales and specific situation of the study area, reflectance properties of the local land cover types, landscape structure and heterogeneity vary significantly. Therefore, in the current research, a comparative analysis of the two was done, in order to analyse, which of them is best suitable to solve a specific task of land cover types detection in western Turkey.

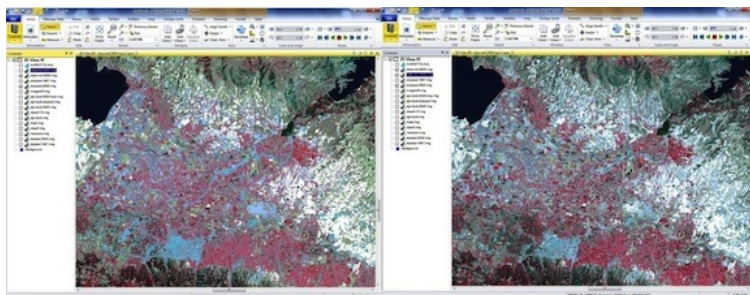


Fig: Detailed fragments of the AOI area from the classified Landsat TM 2000 image illustrating two classification methods: Maximal Likelihood (left) and Minimal Distance (right)

Training sites have been created for the respective land cover types that are typical for the study area in Izmir surroundings (Fig.6). The representative sample sites of known 12 cover types, were recognized on the image and manually digitised. These areas are used as a digital interpretation key that indicated the 'ideal' spectral signatures for the respective land cover classes, according to their individual characteristics.

Subsequently, the whole image was classified using Erdas Imagine. It was done using automatic comparison of each pixel within the image to each 'ideal' land category in the training sites, and then assigning all pixels to the classes to which they best corresponded. The difference between the MD and ML methods consists in the mathematical approaches of this comparison and the method of the class categorisation. The logical idea of the MD classification approach is in calculation of the distance in Euclidean coordinate systems from the values of every pixel to the value of mean vector. Mathematically, the calculation is based on the Pythagorean Theorem. The ML classifier has more statistical than geometrical character. It estimates the greatest probability of each pixel to approach the model group, which is represented by the normally distributed Gaussian Curve, i.e. core training areas.



Fig: Fragment of the Landsat image: 1987 (left) and 2000 (right)

According to the received results, the MD method provides much better and detailed results of the classes division than the ML one. Consequently, the main classification was further performed using the MD method.

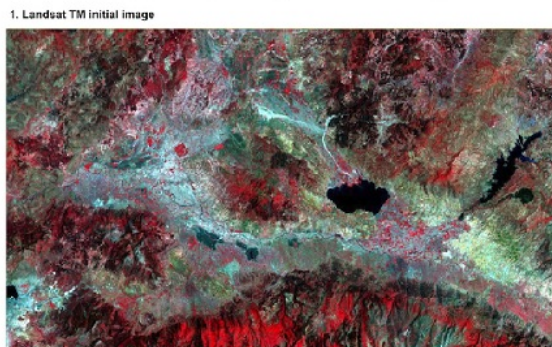
Findings

The final thematic mapping is based on the results of image classification: visualizing landscape structure and land cover in the study area. At the final working step, the areas covered by diverse land cover types were calculated and compared using Erdas Imagine functionality. The assessment of the areas of all land cover classes has been done using calculation of the pixels in each corresponding land cover class multiplied by spatial resolution of the Landsat images.

As a result, following conclusions were received. Croplands (wheat) covered 2382 ha in 1987, which is less than in 2000 (3345 ha). The same increase in other cropland areas is noticeable for the crop class "barley": 4423 ha in 2000 as compared to 1149 ha in 1987. Furthermore, there is noticeable increase in sparsely vegetated areas. The land cover under "coppice" has decreased significantly, which can be explained by the expansion of the agricultural lands. In 1987, coppice covered 5500 ha while there are only 700 ha in this land type at the later stage. Another clear example of the land cover changes: the third type of agricultural areas (cotton etc) increased from 700 to 4813 ha during these years.

As can be noticed in case of the final thematic maps (Fig.7 and Fig.8), the landscapes in the study area of Izmir region are highly heterogeneous and fragmented.

LAND COVER TYPES IN PROVINCES MANISA AND IZMIR, WESTERN TURKEY.
Supervised classification applied to Landsat TM image, 1987.



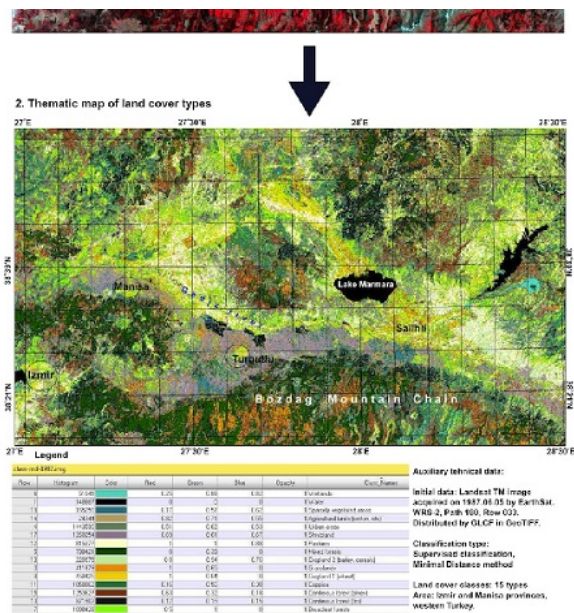


Fig: Final map: classified Landsat TM 1987 image (above) and thematic map of land cover types (below)
 The quality control and validation of the results has been performed using accuracy assessment operations in Erdas Imagine.

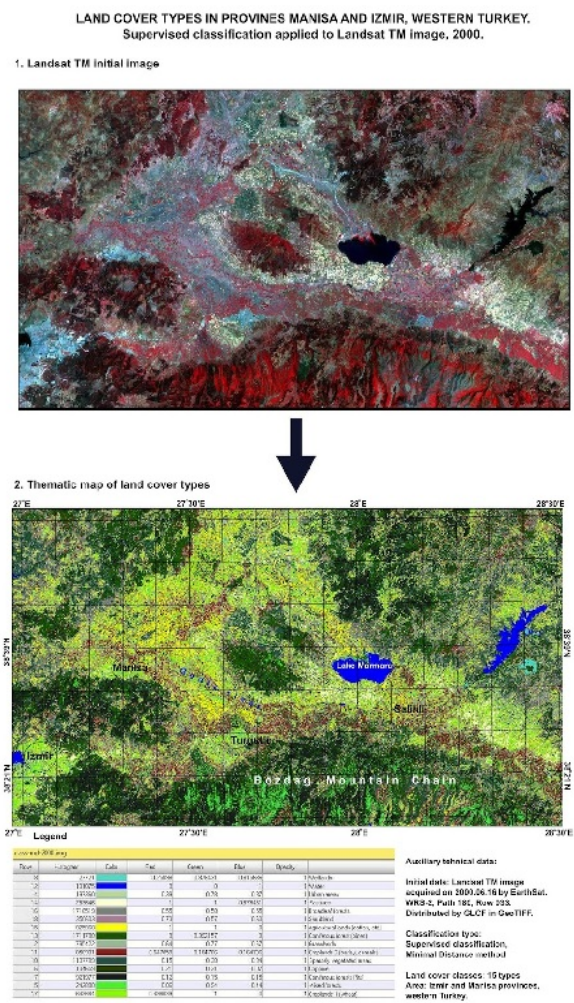


Fig: Final map: classified Landsat TM 2000 image (above) and thematic map of land cover types (below)

On the contrary, there is a noticeable decrease in the forest areas. The broadleaf forests have decreased slightly from 8923 to 5710 ha. The coniferous forests (firs) remained almost unchanged, and there is slight increase in the pine forests. At the end of the study, the accuracy assessment was performed to estimate the preciseness of the classification.

Land Cover Class	No of 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

Table: Changes in land cover types since 1987 until 2000

Conclusion

The increased human activity, such as agricultural work, city spread and industrialisation affect environment, cause negative impacts on the ecosystems and make changes in vegetation coverage. Besides, climate change also affects land cover types, since there is a trend towards decrease of woody vegetation, which was typical earlier for these latitudes.

This article reported studies on land cover changes in the selected area of Izmir region. The results indicate changes in certain land cover types which illustrates impact of anthropogenic activities on the natural ecosystems. Land cover types at various landscapes of Turkey are recently changing due to the complex set of multiple factors such as geomorphic hazards, soil depletion, vegetation degradation, deforestation, natural climatic and other external factors, as well as anthropogenic activities and impacts (both industrial and touristic ones).

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