

# GIS BASED ANALYSIS OF LANDCOVER CHANGES ARISING FROM COAL PRODUCTION WASTES IN ZONGULDAK METROPOLITAN AREA-TURKEY

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### ABSTRACT:

Zonguldak Metropolitan Area (ZMA) is located in North-western part of Turkey and a mining and industry region which occupies the 80% of the Zonguldak Hardcoal Basin (ZHB). In this region, hardcoal mining has been made since 1848 and, based on the records kept since 1865, 328 million tons pit run coal have been produced. Resulted amount of waste from the processing of coal in the coal washing factories is about 114 million tons. Some parts of these coal wastes have been stocked along the coastal lines in ZMA by governmental and private companies while the others have been stored in the valleys and hilly side of inner regions. Additionally, waste materials have been used as filling materials in road and plant constructions.

In this study, coal waste areas and use of wastes in the settlement areas have been determined by means of the analysis carried out on the Landsat TM images of the region using object-oriented image analysis program eCognition 3.0. After segmentation and required classification procedures, results are integrated to GIS environment. At this phase, classified images are superimposed with the high-resolution Ikonos images and then necessary analyses have been realized. Based on the findings, in ZMA, in 1992, there was about 2.1 sq.km coal and coal waste areas, their dimensions increased to 4.2sq.km in 2000. In the urban areas, while the size of coal waste cover was about 9.7sq.km in 1992, it was measured as 16.5sq.km in 2000.

## 1. INTRODUCTION

Based on the statistics from 2000, ZMA is a metropolitan area with 70 sq.km size and consist of 5 sub-settlement units in which 176511 population lives (Erkin 1999). 20%, 20%, 40%, 7% and 15% of ZMA are covered by forested areas, settlements neighbored to forested areas, industrial site, agriculture area and coal waste and idle part respectively.

ZTH contains ZMA is the only hardcoal production basin in Turkey. This basin covers an area of 10000sq.km which extends in 20 km width from east to west. However, 80% of the production takes place in the ZMA. While the hardcoal reserve is about 0.25% of world reserve, amount of total production has been only 10% of the world production (DPT report 1996 and www.taskomuru.gov.tr 2004). In the basin, until the 2004, total amount of production is 412 million tons and decomposed waste is around 143 million tons. Corresponding amounts for ZMA is 328 million tons production and 114 million tons waste respectively. Amount of annual production and waste are given in Table 1.

In this study, first, Landsat-TM images of the interest area was segmented, and then classified. Afterwards, they superimposed to high-resolution Ikonos image with the required queries which results necessary statistics for temporal analysis.

Year	Annual Pit Run Production	Total Pit Run Production	Annual Waste	Total Waste
1865-92		365271539		129152730
1992	4790719	370062258	1961553	131114283
1993	4608668	374670926	1824880	132939163
1994	4210622	378881548	1384559	134320722
1995	3251570	382133118	1003400	135324122
1996	3320074	385453192	897090	136221212
1997	3118688	388571880	813205	137034417
1998	2865824	391437704	736672	137771089
1999	2601175	394038879	654502	138425591
2000	3196564	397235443	940337	139365928

Table 1. Amount of total and annual production and waste from tons unit in ZTH.

## 2. METHODOLOGY

In this study, two types of images have been used. First one includes the Landsat images (only bands 1,4 and 7) dated as 1992 and 2000 with the ground resolution of 30m. These spectral channels were analysed by PCI Geomatica V9.1.1 software package. In these analyses maximum likelihood classification technique was used (Lillesand and Kiefer, 2000). Second one is the pan-sharpened Ikonos images with 1m pixel size.

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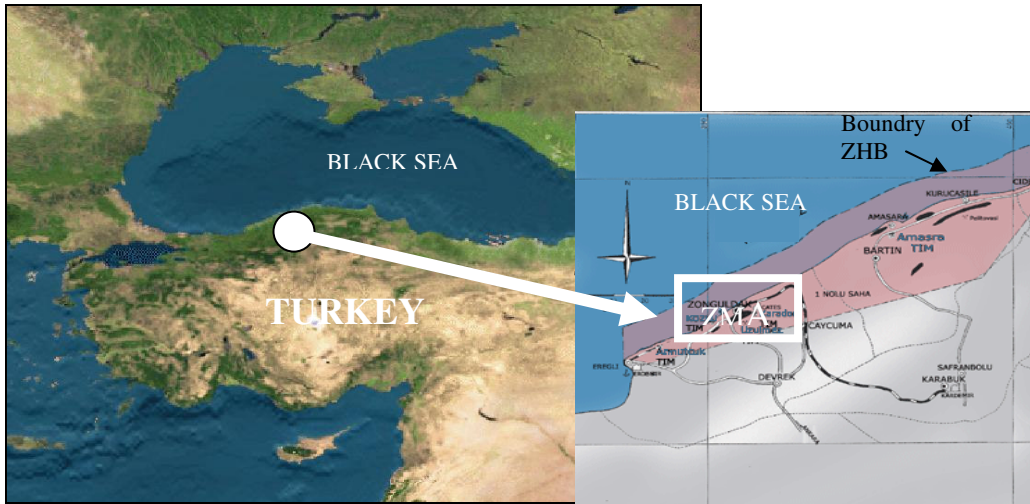


Figure 1. Location of ZMA and ZTH.

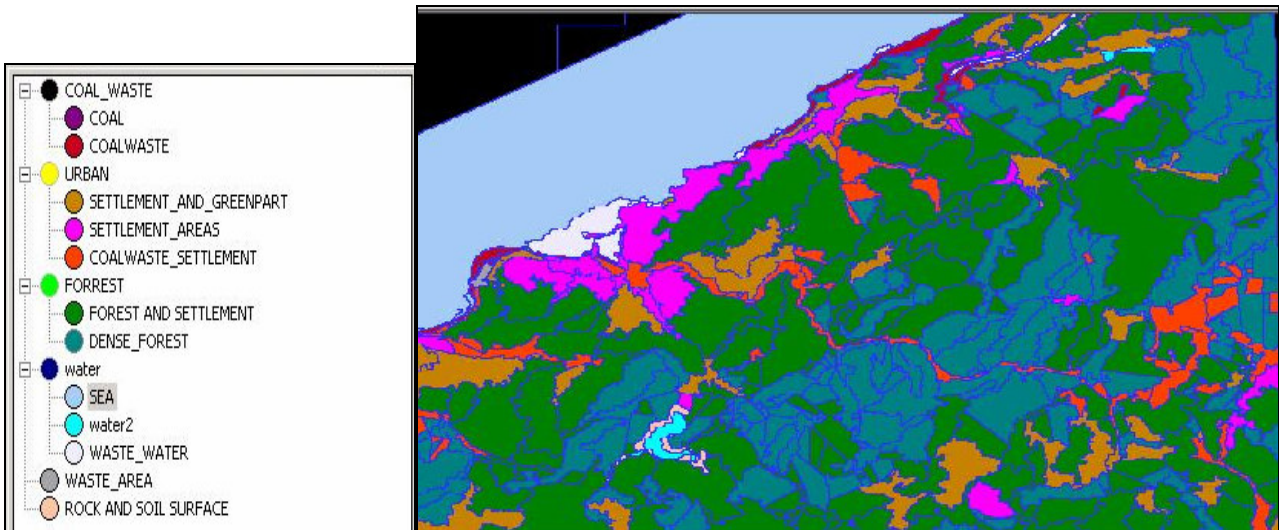


Figure 2. Segmentation and classification results from eCognition software for 1992 Landsat TM image

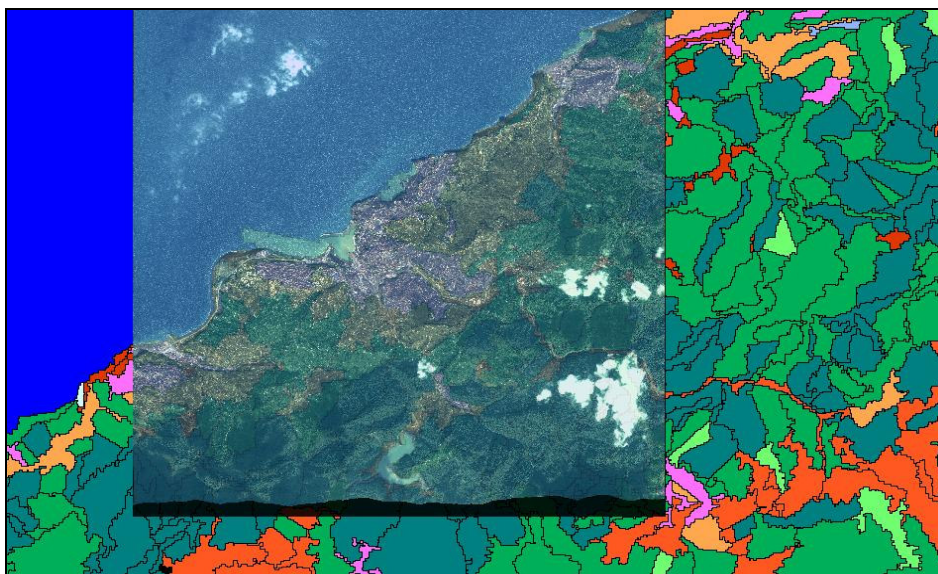


Figure3. Ikonos image superimposed to the classification map in GIS

In the experimental phase, following strategies have been used:

- Landsat images are analysed based on the object-oriented approach using eCognition 3.0 software (Benz, 2004). At this stage; scale, color, shape, smoothness and compactness parameters have been assigned as 30, 0.8, 0.2, 0.9 and 0.1 respectively. After automatic segmentation, in differentiation of pure settlement areas and areas with coal waste, unsolved segments are manually corrected and thus, vectorized classes are derived. These classes are shown in Fig.2.
- Vectorized classes are superimposed onto the pan-sharpened Ikonos image using MAPINFO 7.0 software (Fig.3).
- Topology is created by relating the database which was made for coal, coal-waste and settlement areas.
- Under the GIS environment, coal and coal-waste are selected by query and then they superimposed onto the transparent Ikonos image (Fig. 4a, 4b, 5 and 6) with the required statistics. From this work, it is determined that the size of coal and coal-waste areas have been increased to 4159800.0 m<sup>2</sup> in 2000 from 2102400.8 m<sup>2</sup> in 1992.
- Areas with coal-waste have been selected by query, and then this was superimposed onto the transparent Ikonos image (Fig.7a and 7b). Such a procedure will allow controlling the classification (Fig 8a and 8b) and also deriving the necessary statistics. From the obtained results, the dimension of the coal-waste areas extended to the 16450200.0 m<sup>2</sup> in 2000 from 9749703.76 m<sup>2</sup> in 1992.

## 2. CONCLUSIONS

In this study, based on the classification of satellite images, temporal analysis of coal and coal-waste areas has been carried out between 1992 and 2000 under GIS environment with the required query and analysis. The acquired results are as follows:

- Coal and coal-waste areas in ZMA are shown two times areal increase in 8 years period.
- The dimension of the areas with coal-waste increased 1.7 times and this generated an

improvement in the use of such areas in the urbanized part.

- The size of the area where coal and coal-waste occupy has reached to 7% in ZMA, it is also realized that the 24.2% of the area is covered partly by the coal and coal-waste.

Acquired statistics also verify the environmental problems in the region. Coal solid wastes stocked in the shore line are transported with tides into the sea. The granular materials are then deposited on the seabed where plantations and environment of sea-habitants occupy. This situation influences the fish population and species negatively.

In the past, people had swum in the coastal side, these areas are become forbidden for swimming in years of 2000. Apart from these, materials stored in the inner regions cause tarnishing in the surface waters. Moreover, coal waste particules suspended in the air affects the human health negatively.

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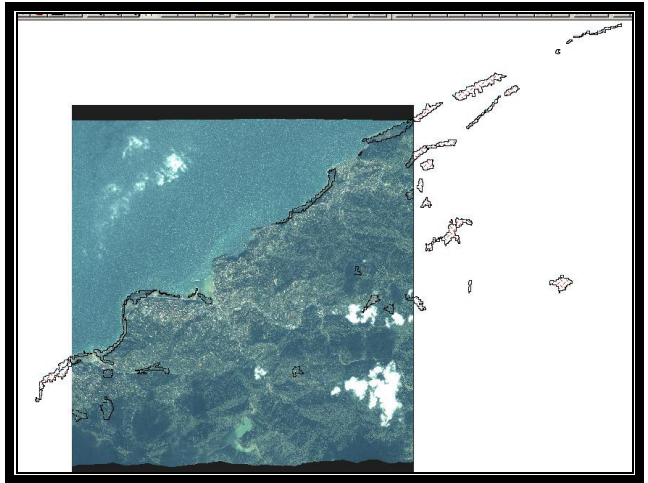
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4 a (1992 segments in GIS)



4 b (2000 segments in GIS)

Figure 4. Coal and Coal-waste areas in ZMA derived from 1992 and 2000 Landsat TM images

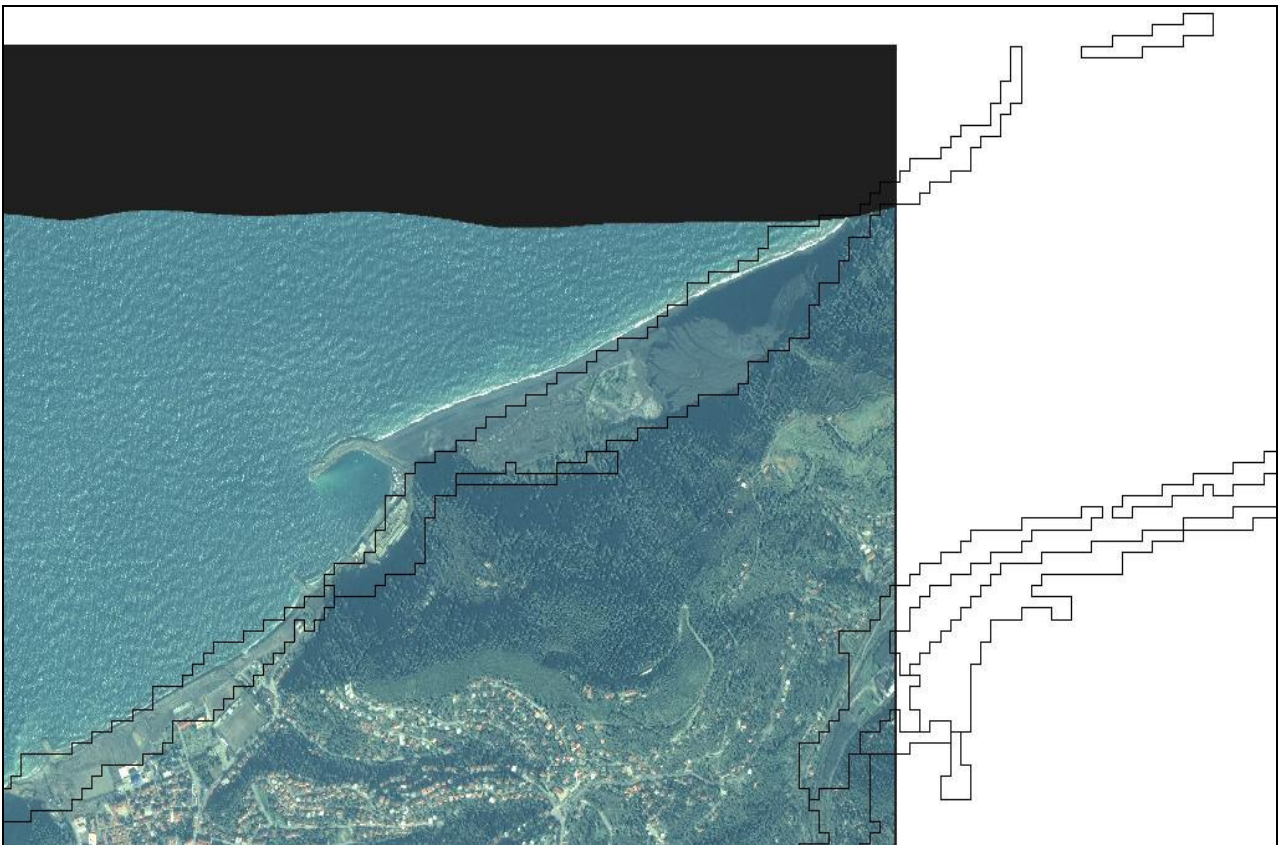


Figure 5. Ikonos image superimposed to coal and coalwaste segmented image of 1992 in Alacaagzı coast of Kilimli-Catalagzı region of ZMA.

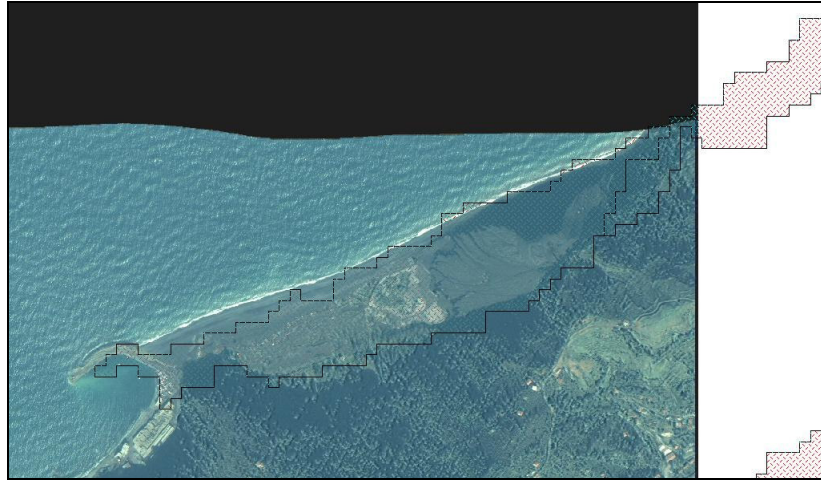
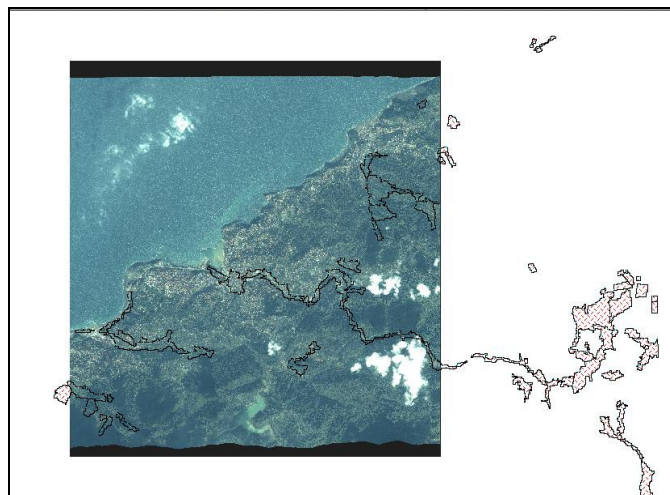
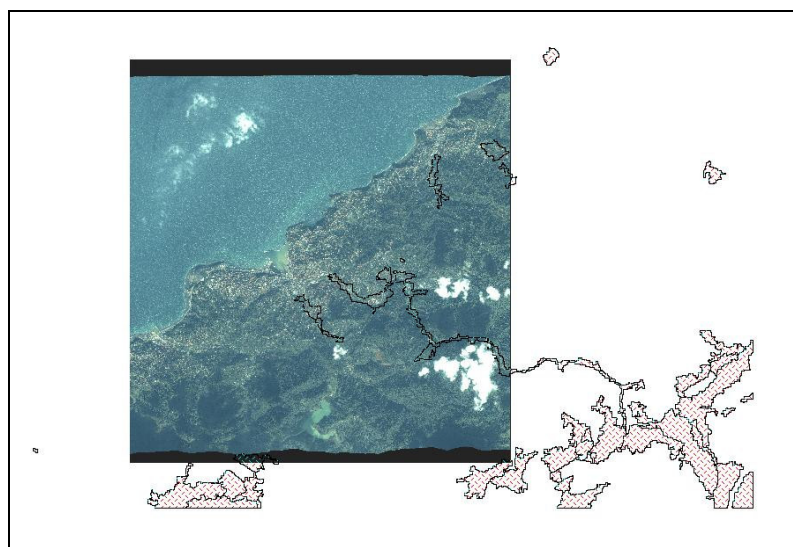


Figure 6. Ikonos image superimposed on to the coal and coal-waste segmented Landsat image of 2000 in Alacaagzı coast in Kilimli-Catalagzı region of ZMA. From this image, port construction in the east of Kilimli coast and existence of increasing garbage masses on the coal waste in Alacaagzı beach can be seen clearly.



7 a



7 b

Figure 7. Ikonos image superimposed on to the segmented Landsat image of 1992 and 2000 for coal-waste and settlement classes.



8 a



8 b

Figure 8. Ikonos image superimposed on to the coal-waste and settlement Landsat image of 1992 (8a) and 2000 (8b) in Uzulmez region of ZMA. In fig. 8a, center area of image is does not contain coal-waste and settlement class. However, in the 2000 classified image, this area is shown as coal-waste and settlement class.