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**Remote Sensing for Science,
Education, and Natural and
Cultural Heritage**

Forest Fire Damage Estimation Using Remote Sensing and GIS

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Introduction

- Forest fires can be considered as one of the most important environmental hazards.
- Natural or human-induced fires affect the natural ecosystem and wildlife significantly. Fires also threaten human life directly especially if the settlements are close to burning area and indirectly by destroying the forests which are the suppliers of oxygen.
- Aegean and Mediterranean regions have been facing forest fires frequently due to continental climate conditions with hot and dry summers.
- Forest fires are a recurring phenomenon in Turkey and according to statistics given by Turkish Ministry of Environment and Forestry 1.571.609 ha forest area were burnt as a result of 80012 fires since 1936.

- Rapid estimation of damaged area and its spatial distribution is essential for evaluating the impacts of fire in landscape and biodiversity
- Determination of burned area also provides land cover change information of ecology, which is important data for post fire restoration of the region
- Remote sensing technology can be used in different phases of fire management which are risk estimation, detection and assessment.
- Remotely sensed data provide rapid, accurate and reliable information for post – fire damage analysis with being spectrally sensitive to surface vegetative characteristics and structure.
- In this research, the damage of a forest fire occurred on 10th August 2009 in Seferihisar district of Izmir, Turkey, was analyzed using remotely sensed data, topographic data and ground truth data.

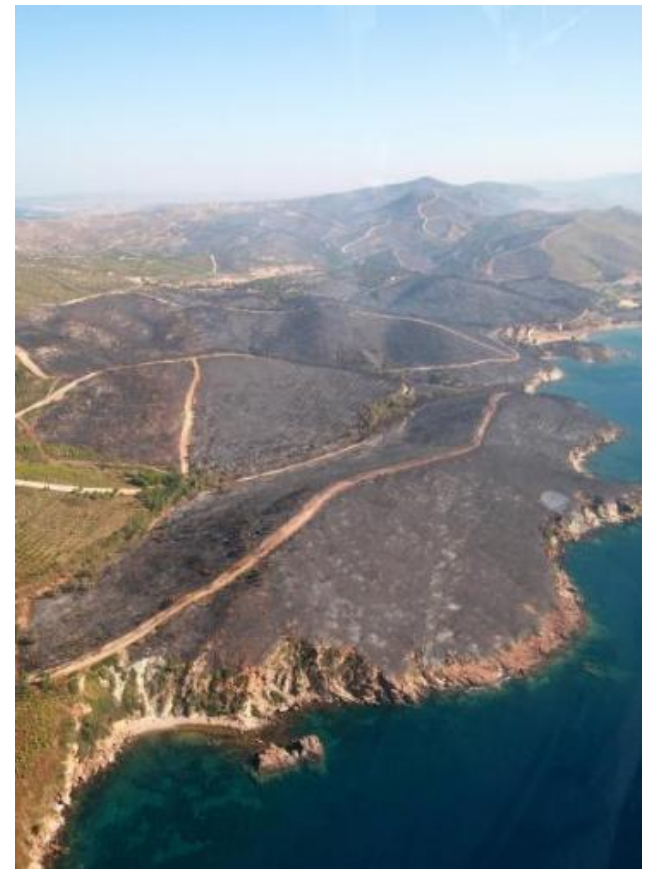
Study Area

- Seferihisar is a district of Izmir that resides in Aegean Region of Turkey.
- Topography of the district shows a complex characteristic with changing elevation from sea level to 680 m in Cakmaktepe Hill.
- Climatologic properties of district are in coherence with general properties of Aegean Region. Annual maximum temperature recorded for the district in July with 35.2 C°. Annual wind speed is nearly 12,6 km/hr and relative humidity is 64%.



Fire Phenomenon

- A forest fire started with unknown reason at shrub area and spread a wide area with impact of 60 km/hr speed strong wind on 10th August 2009. Fire was extinguished after 17 hours fire fighting work.





Data Used

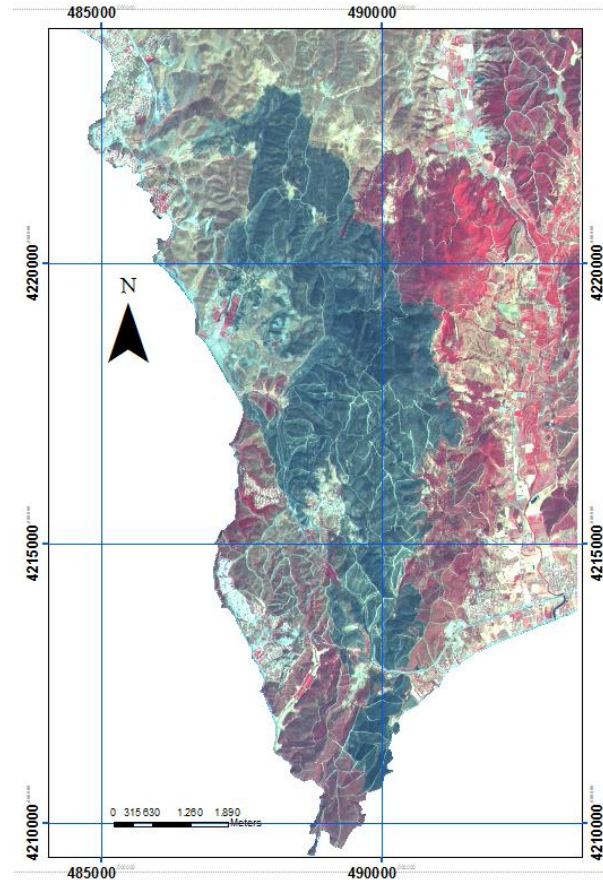
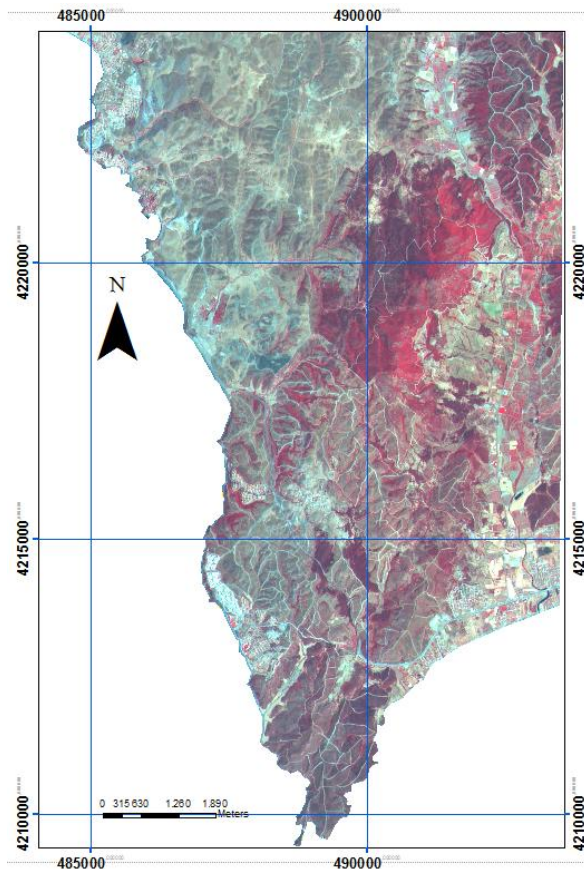
- SPOT 4 Images (01.08.2008 and 31.08.2009)
 - 20 meter resolution Multispectral (MS)
 - red (B1) green (B2) and near infrared (B3 and B4) wavelength portions.
 - 10 meter resolution panchromatic (PAN) band
- ASTER GDEM
 - 30 m resolution Global Digital Elevation Model derived from ASTER stereo images.
- Ground Truth Information
 - climatic annual records,
 - stance maps
 - photographs taken after fire

Methodology

- Preprocessing
 - Orthorectification
 - Pansharpening
- Spectral Analysis
 - NDVI Analysis
 - Spatial Profile Analysis
- Image Classification
 - Unsupervised ISODATA Classification
- GIS Analysis
 - Raster – Vector Conversion
 - Overlay Analysis

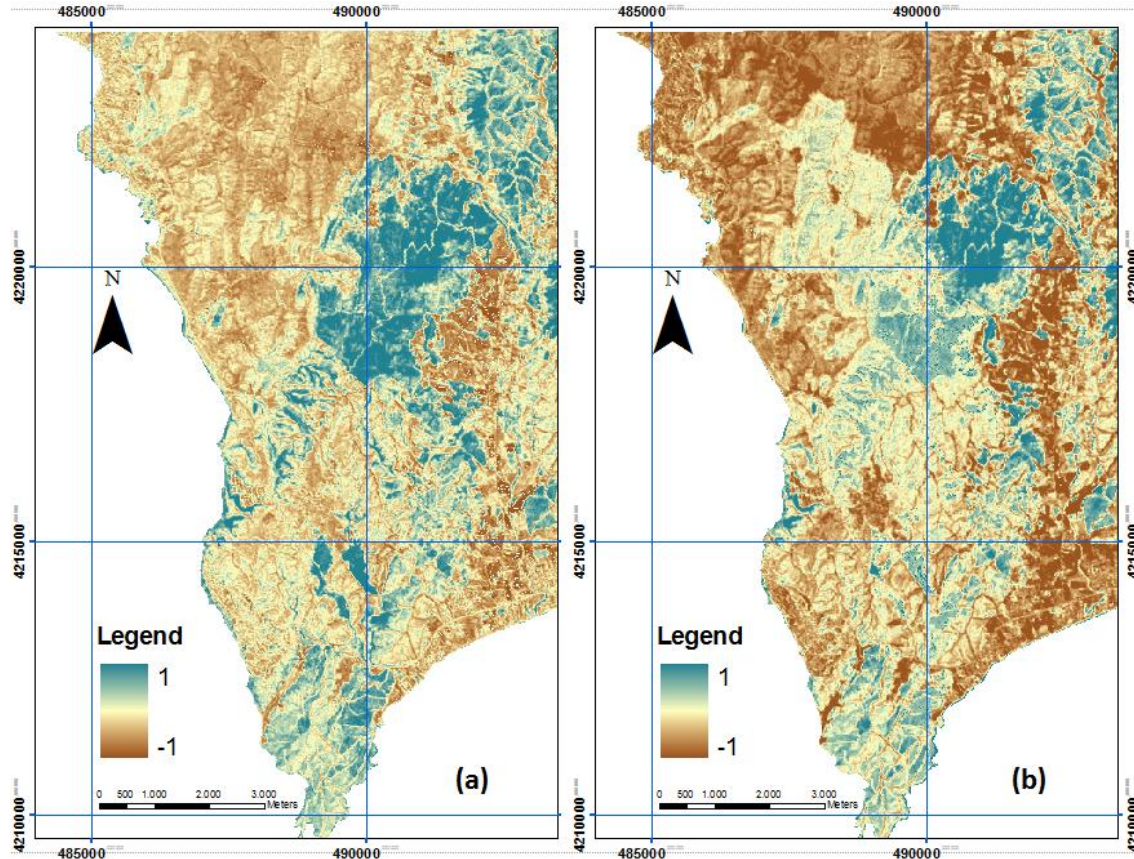
Preprocessing

- Orthorectification of pre- and post-fire satellite images were conducted using ASTER GDEM data and Ground Control Points (GCP) obtained from 1:25.000 scaled topographic maps. The root mean square error (RMSE) values were $\pm 0,40$ and $\pm 0,28$ pixels, respectively.
- MS and PAN datasets belonging to same date were pansharpened in order to be used for image classification.



Spectral Analysis

- Vegetation indices based on quantitative analysis of vegetation health and biomass density, using spectral values from satellite imagery. These indices commonly use photosynthetically active image wavelength portions, which are NIR and Red. The result of ratio based indices is an image with pixel values between -1 and +1. High values in resultant images indicate healthy vegetation.



$$NDVI = \frac{NIR(3) - RED(2)}{NIR(3) + RED(2)}$$

- In the first transect, Pre-fire NDVI values are positive values ranging from 0.05 to 0.25 representing healthy vegetation. However, post-fire NDVI values are mostly negative values representing the burnt areas. In the second transect belonging to unburnt area, NDVI values, so the graphics are very close.

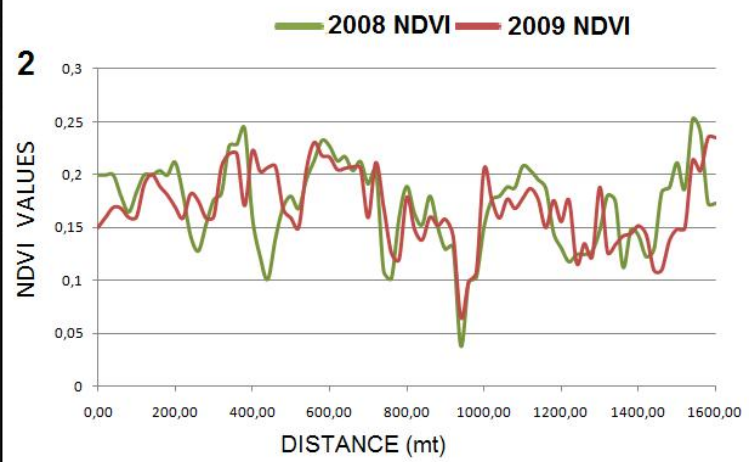
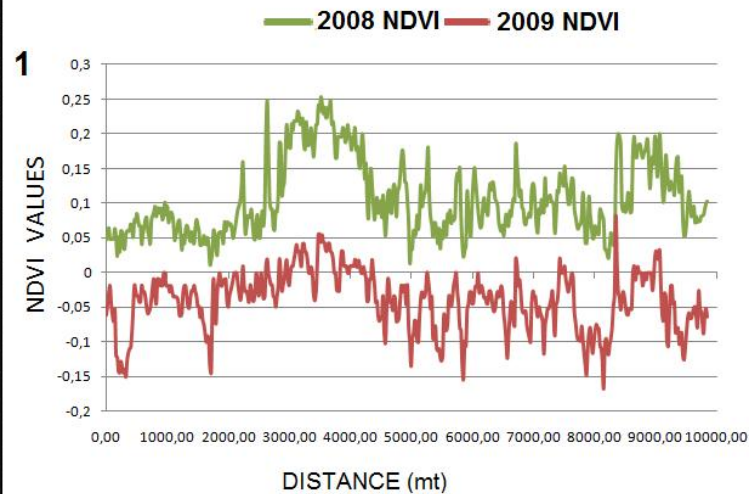
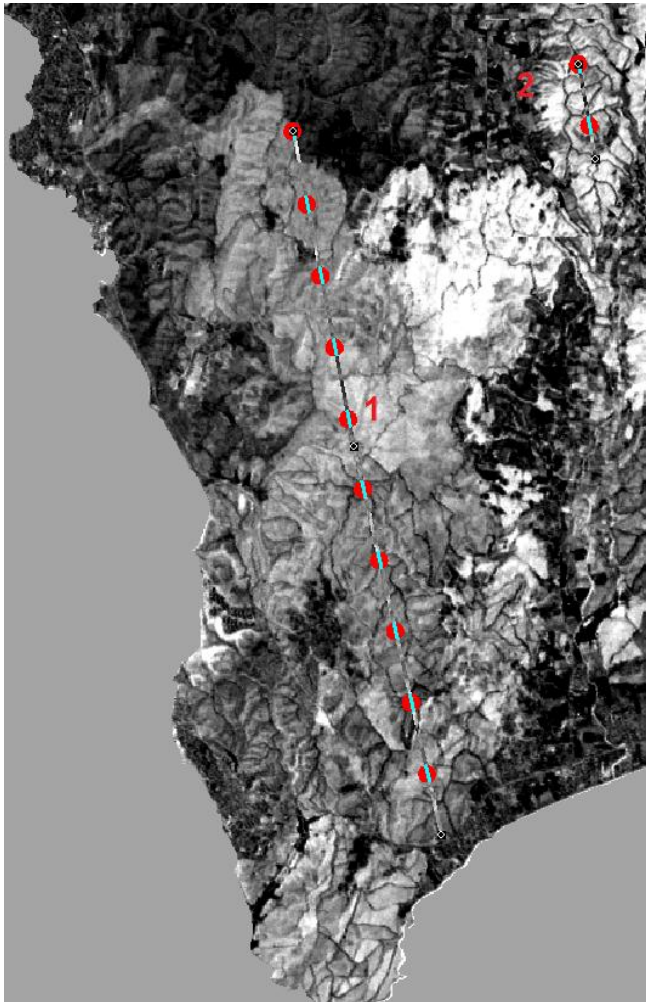
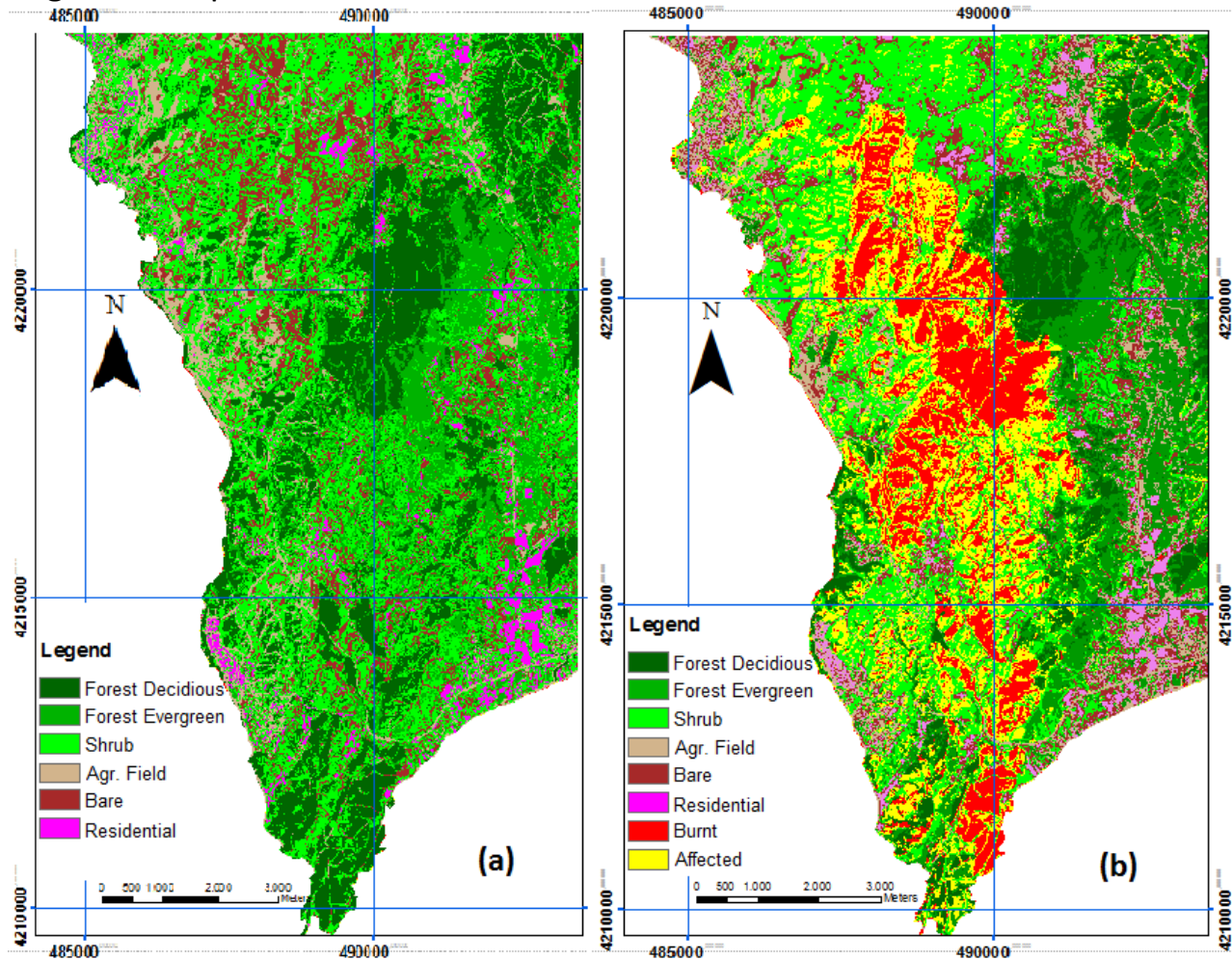


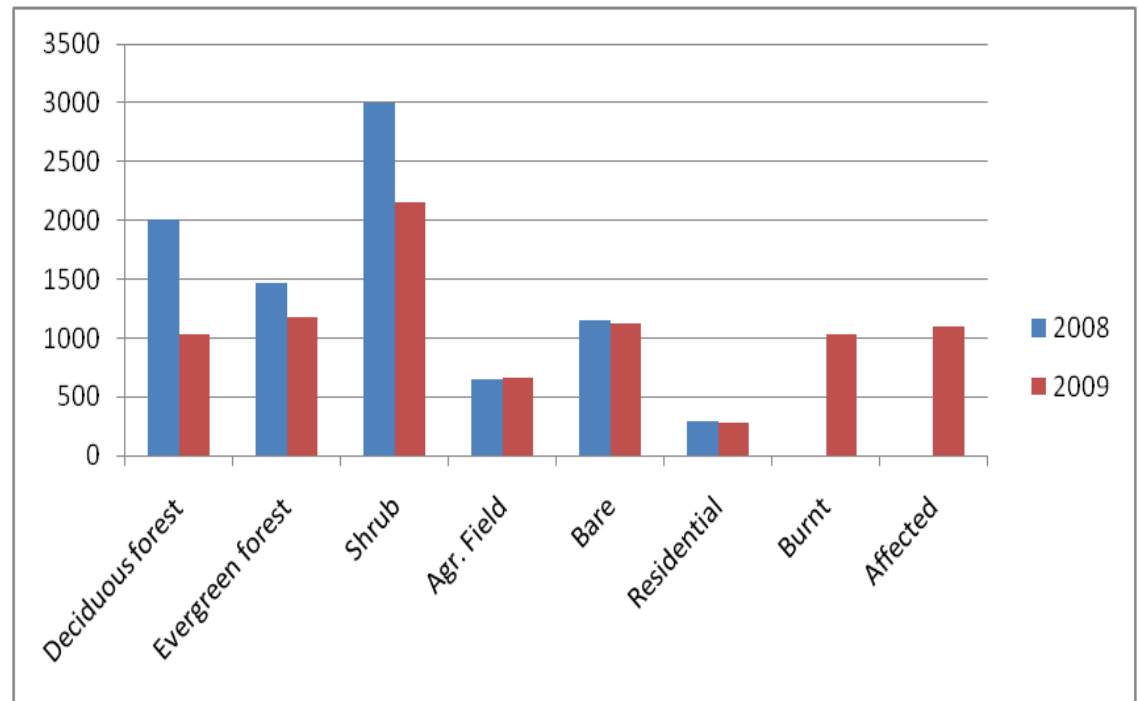
Image Classification

- Orthorectified and pan sharpened SPOT 4 pre- and post-fire satellite images were classified using Iterative Self-Organizing Data Analysis Technique (ISODATA) classification process. 20 initial clusters were created with 0,99 convergence threshold. The results were interpreted visually according to ground truth information and clusters combined to form final thematic classes namely deciduous forest, evergreen forest, shrub, agricultural fields, bare, residential, burnt and affected, using recode operation



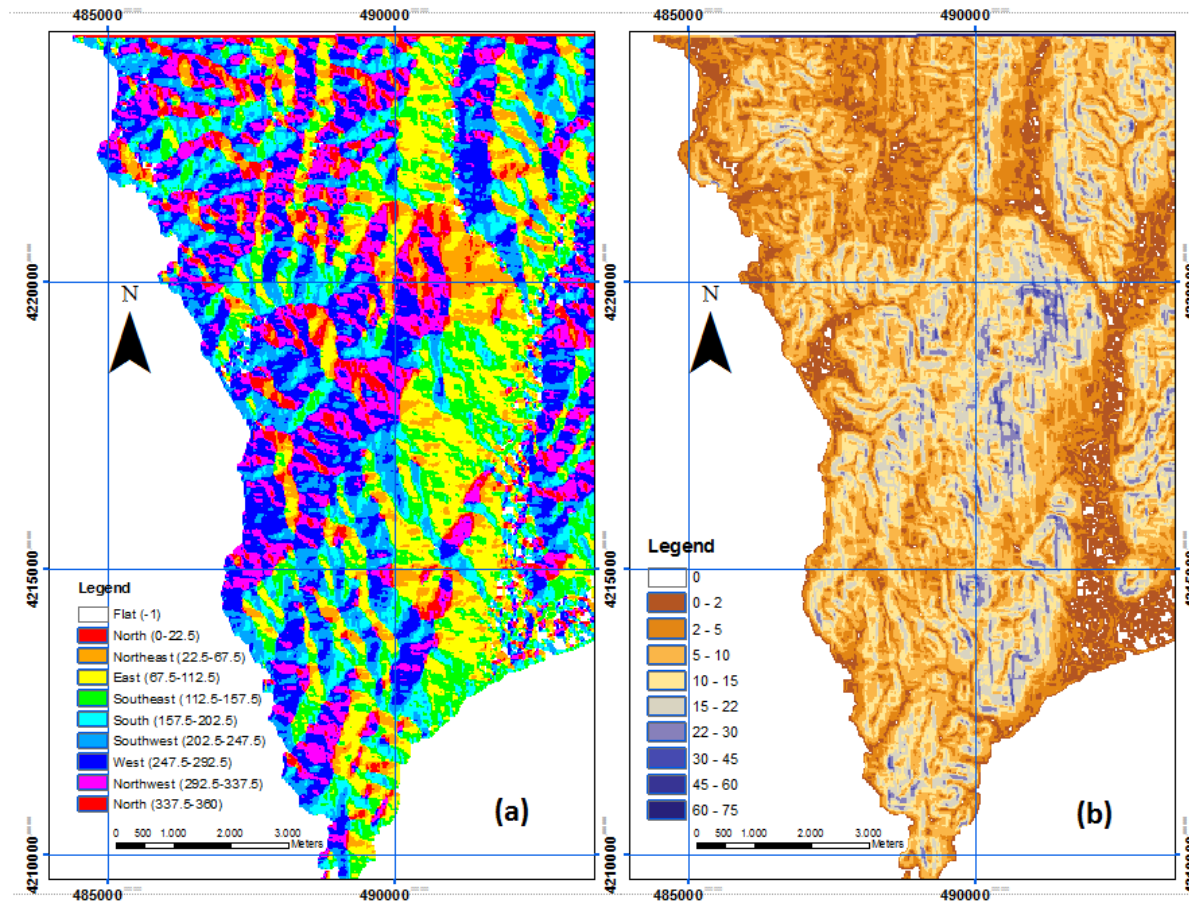
Classification Results

	2008 (ha)	2009 (ha)
Deciduous forest	2014,37	1038,73
Evergreen forest	1466,67	1179,53
Shrub	3000,07	2150,77
Agr. Field	652,84	664,04
Bare	1148,09	1119,34
Residential	289,29	283,56
Burnt	0,00	1035,51
Affected	0,00	1099,85
TOTAL	8571,33	8571,33



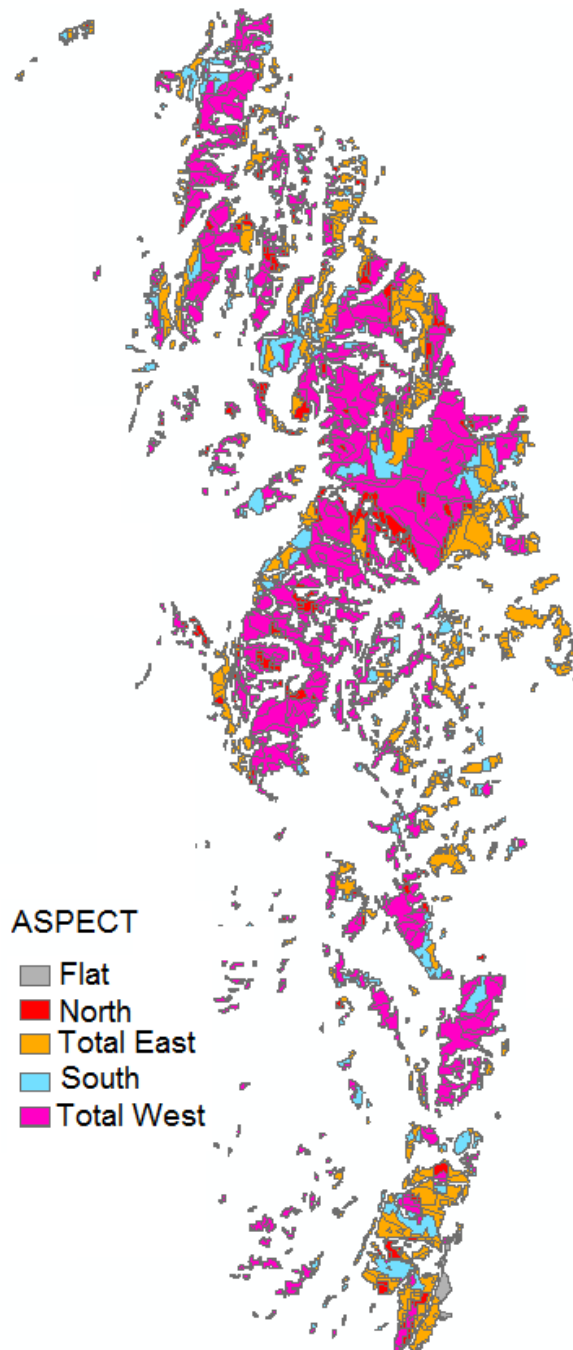
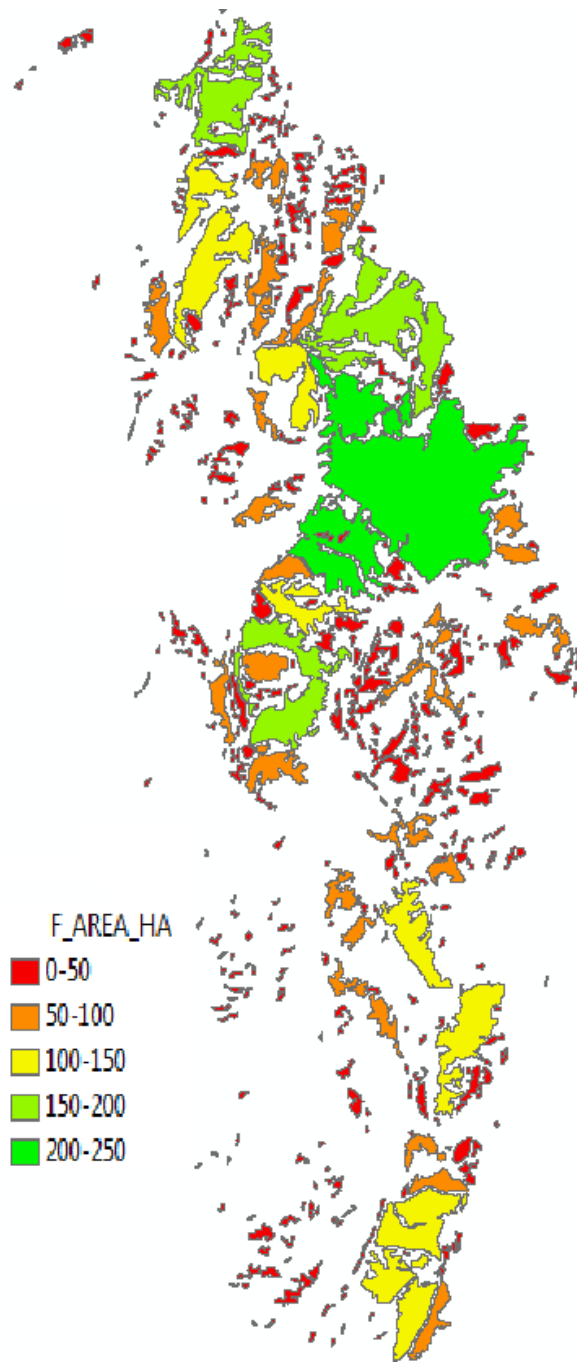
GIS Analysis

- Classification results and topographic information of the study area were subjected to GIS analysis in order to determine the relationship between topographic characteristics of the region and fire spatial distribution and magnitude. For this aim, aspect and slope maps were created from ASTER GDEM data.

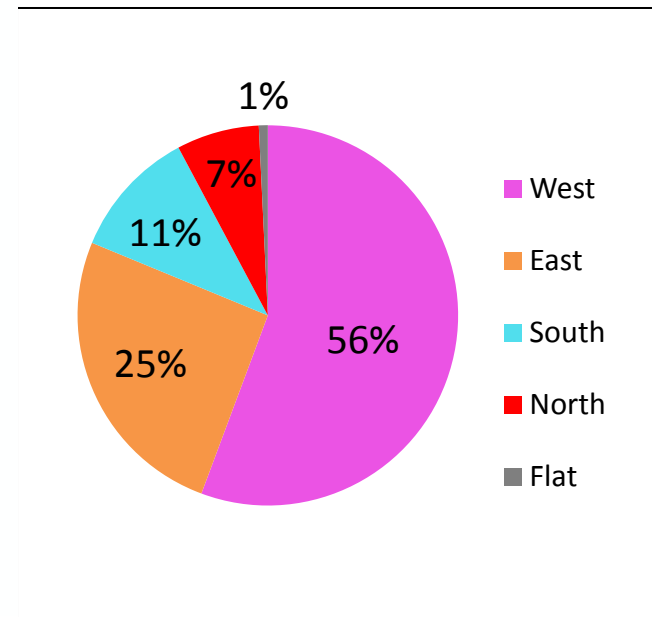


- Thematic classes obtained from classification process were converted to vector data from its original raster form.





- In the left side, magnitudes of the burnt zones were presented as spatial map and numeric values in hectare unit.
- In the right side, locations of the fire damaged areas were presented in relation with the aspect map showing the orientation of topography.



Results and Discussions

- According to results of this study, analysis of remotely sensed data provided valuable information for determination of the damaged areas after the forest fire occurred in Seferihisar District.
- Firstly, orthorectified MS data were processed to obtain NDVI data. Level sliced NDVI results indicated dramatic decreases over burnt areas that can be interpreted as completely destroyed vegetation. Second level of decrease in NDVI values were corresponded to affected areas. Pre- and post- NDVI images were layerstacked and spatial profile obtained from this data along a section confirmed the decrease.
- Secondly, unsupervised ISODATA classification algorithm was applied to orthorectified pre- and post- images. Resulting images were tested and verified using ground truth information and aerial photographs taken just after fire. Land cover changes between two dates were determined in hectare units and a change detection histogram was created using this information. Spatial distribution of burnt and affected areas showed a strong relation with NDVI data and ground truth information.

- In the third step, GIS analysis performed in order to correlate the magnitude and spatial distribution of fire with topographic parameters of the area. The result of overlay analysis with aspect map agrees with wind direction information obtained from Turkish State Meteorological Service that states the wind direction as west direction.
- The results of this research showed that, remotely sensed data is an important source to estimate and map the damaged and affected areas. Integrated usage of remotely sensed data and ground truth information give valuable information about spatial distribution and areal extends of the fire damages.
- In addition, land cover changes after the fire can be easily monitored with the use of multitemporal imagery being important information to understand the affects of fire on ecology and biodiversity.
- GIS environment provides a suitable platform to understand and correlate topographic information with satellite imagery and enables to perform analysis for identification of orientation and distribution of the fire.
- The results of these analysis can be presented as maps and statistical numeric values which are indispensable representation approaches of information for scientists and policy makers.

Thanks for Your Attention

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