Pre and Post Earthquake Forest Damage Assessment – A Case Study of 2005 Earthquake Impact on Forest of Machiara National Park, Pakistan

Urooj Saeed, Kaif Gill, Hassan Ali, Hammad Gilani and Naeem Shahzad
WWF - Pakistan
P.O. Box 5180, Ferozepur Road, Lahore, Pakistan.

Abstract—**October 2005 earthquake in Pakistan measuring at 7.6 Richter scale jolted huge area of Himalayan Mountains leaving over 75 thousands people dead; 80,000 people injured and about 3.5 million people as homeless. It not only destroyed buildings, telecommunication, roads, and power supply but also hampered the natural resources of the area. Current study aims to analyze the forest damage caused by earthquake, massive aftershocks and post land sliding in Machiara National Park. Machiara National Park (MNP) is situated in the Himalayan Highlands in Muzaffarabad District of Pakistan. It is in the Western Himalayan Broadleaf forest region and is one of the Global 200 Ecoregion. For the forest damage assessment, satellite images of 2000, 2005 and 2007 are being used. An extensive filed visit of the area was conducted to collect ground truth data. Pre and pots earthquake analysis reveal an overall decrease of 3% in conifer forest from 2000 – 2005 whereas 17% decrease from 2005 – 2007 is observed. Increased forest degradation rate due to triggered landslidings (in higher elevation and less forested/barren land) highlights the protective role of forest.**

Index Terms—**Earthquake, Forest Damage, GCPs, Supervised Classification**

I. Introduction

WWF - Pakistan is one of the large and most active non governmental nature conservation agencies in Pakistan. Founded in 1971, WWF - P is one of 30 independent national organizations that form the international WWF family which is headquartered in Gland, Switzerland. WWF caries out conservation activities through the target driven programmes which cover all the ways in which natural environment is threatened:

Forests	Species
Freshwater	Toxics
Marine Ecosystems	Climate change

The October 8th earthquake that jolted almost 30,000 km^2 area of Himalayan mountains in N.W.F.P and Azad Jammu & Kashmir, was one of the most profound and worst earthquakes in the entire history of Pakistan leaving behind over 75 thousands people dead; 80,000 people injured and about 3.5 million people as homeless. The places severely hit by the earthquake were Muzaffarabad, Bagh, Rawlakot, Neelam and Jehlum valleys in AJK, Balakot, Kaghan Valley, Battal, Batgram, Shangla and Kohistan in NWFP [1].

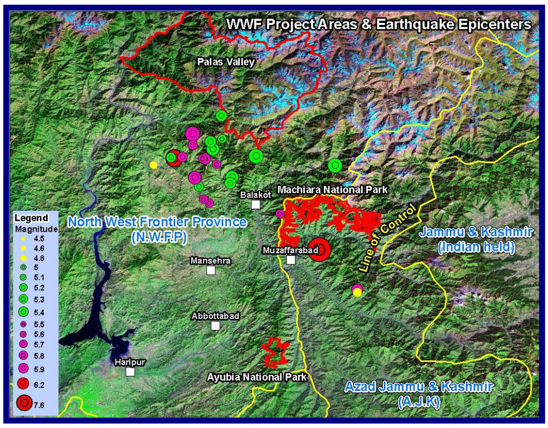

Figure 1: Earthquake epicenter area with magnitude at Richter Scale

Current study was carried out at Machiara National Park (MNP) which lies at 35 km from Muzaffarabad. The Machiara National Park is surrounded by about 28 village communities, in three Union Councils of Serli Sacha, Machiara, and Bheri, with a total population 31,745. MNP falls in the Western Himalayan Ecoregion which is one of the 200 globally important ecoregions ranked by WWF. It offers a wide spectrum of ecological niches from permanent snowfields and alpine pastures to a variety of Himalayan Moist Temperate Forest types [2]. It is a suitable representative and relatively undisturbed area of this ecotype in terms of rich biological diversity. Although the park is famous for rare wildlife such as Snow leopard, Musk deer, Western horned tragopan and Cheer pheasant, yet it is one of the few sites in which a breeding population of the Western horned tragopan pheasant (*Tragopan melanocephalus*) exists [3].

The 8th October earthquake besides irreparable loss of precious human lives brought billions of dollars damage in the infrastructure which would take years to reconstruct. Besides loss of lives and property, there are reports of massive landslides washing away vegetation on the slopes.
Current study aims to assess the forest damage caused by earthquake and its post impacts.

II. STUDY AREA

The Machiara National Park (MNP) lies at 34°-31' N latitude and 73°-37' E longitude, located on the right bank of the River Neelum at about 35 km from Muzaffarabad. Kaghan Valley is on its western side, while on eastern side lies the Neelum Valley. MNP falls in the moist temperate zone with cold winters and deep snow. It houses a broad range of ecological function from permanent snow fields and alpine pastures to variety of Himalayan forest types.

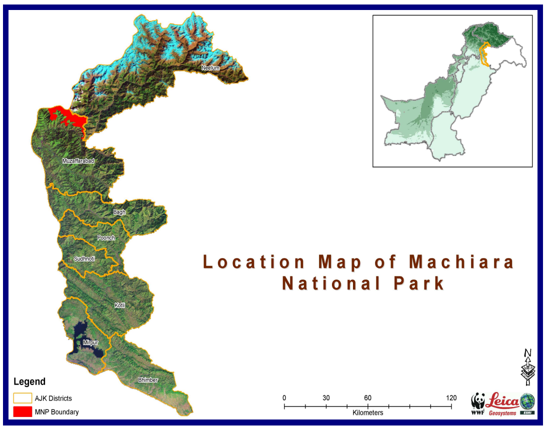

Figure 2: Location map of study area

MATERIALS AND METHODS

Three different satellite images were used in this research. All the images were ortho-rectified in UTM projection zone 43 with spheroid and datum as WGS 84. Information about these datasets is as follows:

Table 1
Satellite data characteristics

Satellite	Sensor	Acquisition Date	Source	Spatial Resolution
Terra	ASTER	14-11-2000	USGS	15m
SPOT-5	SPOT-5	20-10-2005	SUPARCO	10m
Terra	ASTER	10-05-2007	USGS	15m

A. Image Processing

Advance Spaceborne Thermal Emission Reflection Radiometer (ASTER) images were acquired in L1A data level in Hierarchal Data Format (hdf). L1A data are formally defined as un-processed, full resolution and un-rectified digital data [4]. For thematic layer generation through ASTER data, spectral bands of VNIR (1, 2 and 3N) range were imported in .img format. The images were ortho-rectified by using Lieca Photogrammetry Suite (LPS) module of ERDAS Imagine 8.7®. Digital Elevation Model (DEM) of Shuttle Radar Topographic Mission (SRTM) was used for the elevation (y) reference values. SPOT-5 satellite image was also ortho-rectified to assign real world coordinates to the image as well to avoid relief impact. High resolution merge was also applied on SPOT-5 imagery to get better visual details at 2.5m resolution. This high resolution multispectral image was used to develop field maps.

B. Topographic sheet

The GIS layers of contours, populated places, spot heights, drainages and forest boundaries were digitized from 1:50,000 Survey of Pakistan (SoP) topographic sheet. These GIS layers overlaid on the satellite image were very helpful in the navigation throughout the field visit.

C. Field Visit and Observation

A field visit of MNP was conducted from 16th Aug to 1st Sep, 2007. For the field use A2 and A3 paper size, False Color Composite (FCC) maps of SPOT-5 satellite data were prepared. Field maps were developed on 1:25,000 and 1: 50,000 scales with 30 second grid intervals. Garmin 76CSX GPS receiver, digital camera and binocular were used during the field visit. Two hundred and thirty waypoints were collected at different points of MNP. Wildlife inspectors helped in GPS data collection and forest compartments identification in the field.

Some of the field observations are as follows;

1. October 8, 2005 earthquake destroyed MNP forest very badly. Affected trees were scattered everywhere.

Figure 3: Digital photographs of effected area

2. Different types of vegetation species were observed in MNP. In the Conifer forest Blue Pine, Fir, Chir Pine, and Deodar exists. In the National Park, blue pine and fir are the most dominant species of conifer forest (Figure 4).

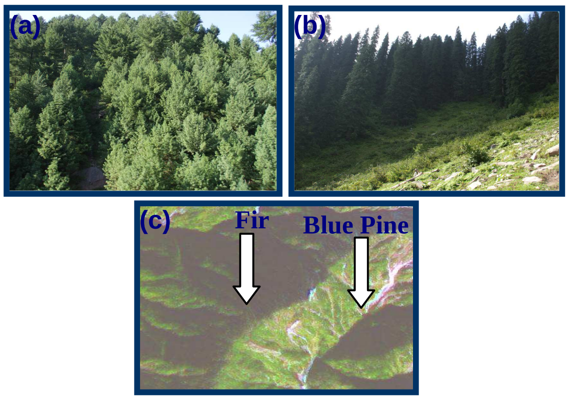

Figure 4: Digital photographs (a) Blue Pine (b) Fir and (c) Satellite Image of Blue Pine and Fir

3. Pastures and grasslands also cover large areas in MNP. Local communities spend their summer season on those

pastures with their livestock due to the shortage of fodder in the villages. Digital photograph and satellite image of a water body in pasture land is shown in Figure 5.

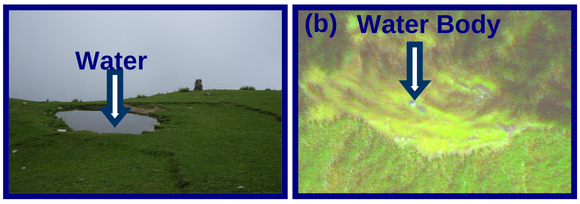

Figure 5: Pasture land (a) Digital photograph (b) Satellite data

4. In MNP relatively smaller area is covered with broadleaved forest mixed with conifer forest (Figure 6). Karkas Cinqana, Akhrot, Bankhor are the main broad- leaved species in the area. Some patches of Karkas Cinqana mixed with Conifer forest was also observed while other broadleaved species were on very small area.

Figure 6: Pasture land (a) Digital photograph (b) Satellite data

5. On pasture lands home steds (huts) were also present. They are not identifiable through the satellite image due to the high spatial frequency.

6. Earthquake (2005) had a drastic impact over an extensive area of the forest cover. According to Qamar (Social Mobilizer, MNP) approximately 5000-6000 trees were damaged by earthquake in Forest Compartment number 8A).

During the field survey it was observed that forest acted as a shield against the earthquake. The land sliding was mostly triggered in the barren areas/sparse vegetative land as compared to dense forest area.

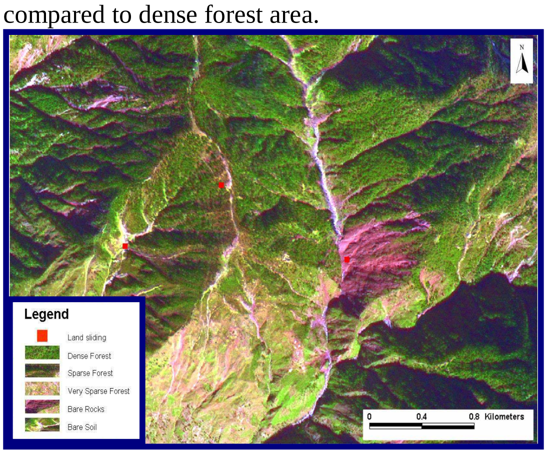

Figure 7: Landsliding observation points

There is a myth that the 2005 earthquake was a result of extensive forest cutting done by the local people. Now they believe that forest is a saving factor and its reduction/cutting will anger Allah, leading to series of disasters.

III. CLASSIFICATION

Satellite Image in digital format allows for numerical processing, analysis and application of multivariate classification methods. Image classification is a procedure to categorize all pixels in an image of a terrain into landcover classes [5]. Spectral values for each pixel in a training site are used to define decision space for each class [6]. Mainly there are two techniques for the spectral classification of satellite imagery i.e. supervised and unsupervised classification.

Supervised classification on multi-spectral imagery was adopted for thematic layer generation of MNP. In supervised classification process, training areas were identified on the basis of field observation. The range of region growing in metric from was controlled through Euclidean distance [7]. Euclidean distance is the spectral distance that is controlled by the analyst for purifying a training sites and training signatures. Sufficient and well scattered training areas of each class were taken on the images. Euclidean distance and homogeneity between the pixels determines the fate of grown region. Different parameters such as visual interpretation keys, ground truth data, feature space and histogram helped to defined accurate landcover.

Spectral signatures show the percentage reflectance of electromagnetic radiation in specific bands. Vegetation biomass due to the presence of chlorophyll reflects more radiations in green and near-infrared wavelengths as compared to the other parts of electromagnetic spectrum [8]. Chlorophyll content varies in different vegetation types and hence percentage reflectance is used to assign specific class to a particular training area. Derived and analyzed spectral signatures were used for the definition of different landcover classes. Spectral signatures of different landcover classes are shown in Figure 8b.

Feature space is a graphical representation in which values of the data of one band are plotted against the data file values of other band. Different colours in feature space represent densities of pixels in image [9]. The brighter tones represent a high density and dark tones represent a low density. Scatterplot of band 1 and band 3 (Fig.8a) were used for the development of landcover map.

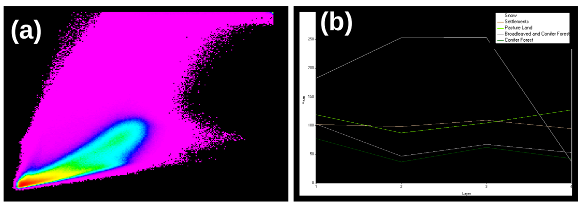

Figure 8: (a)Scatterplot and (b) Spectral signatures of different landcover classes on SPOT satellite image

Each pixel in the image data set was characteristically categorized into a thematic land cover class that closely resembled according to statistical rules defined for the spectral classification scheme.

IV. RESULTS AND DISCUSSION

For better interpretation, output thematic layers were recoded into major landcover/landuse (LCLU) classes given in below table.

Table 2
Area covered by LCLU classes

LCLU Classes	ASTER (14-11-2000)	SPOT-5 (20-10-2005)	ASTER (10-05-2007)
Conifer Forest	7650.79	7417.73	6063.89
Broadleaved and Conifer Forest	488.45	364.65	367.65
Conifer Forest, Shrubs and Grasses	2037.35	2350.75	1563.32
Pasture Land/Grasses	519.93	1280.93	396.23
Settlement and Grasses	1742.35	1543.58	2537.86
Water and Rocks/Shadow	784.07	222.75	955.22
Snow/Clouds	1153.51	896.06	2192.29

Conifer forest, broadleaf forest and pasture lands are permanent land features. Whereas area coverage of grasses, rocks, snow and water vary with season and time.

The results (Table 2 and Figure 9) show that there was an overall decrease of 3% in conifer forest from 2000 – 2005 whereas from 2005 – 2007 is 17%. One of the causes of the forest degradation is its continuous use by the locals. People of the area have been traditionally using the resources of the National
Park from hundreds of years. The main catalyst of 17% degradation in a two year period is mainly due to the post earthquake landslidings and glacier avalanches in high elevation areas. 2005 event not only destroyed large number of trees but also weakened the roots of the trees.

Results show decrease in mix forest class of ‘Broadleaved and Conifer Forest’ from 2000-2005. Broadleaved and Conifer class is representing the mixed zone of the forest which exists in moderate slope areas. Decrease in the forest can be justified by the fact that these areas were easily accessible and considered potential cutting areas by the locals. The forest extent of this class appears sustainable from 2005 – 2007 due to less anthropogenic impact on the forest.

The analysis clearly describes the protective role of vegetation cover in hilly areas. This exercise greatly serves to explain the shielding impact of forest against earthquake in the mountainous terrain. It is quite clear from the study that avalanches and landsliding triggering impact was less in forested areas as compared to the barren land.

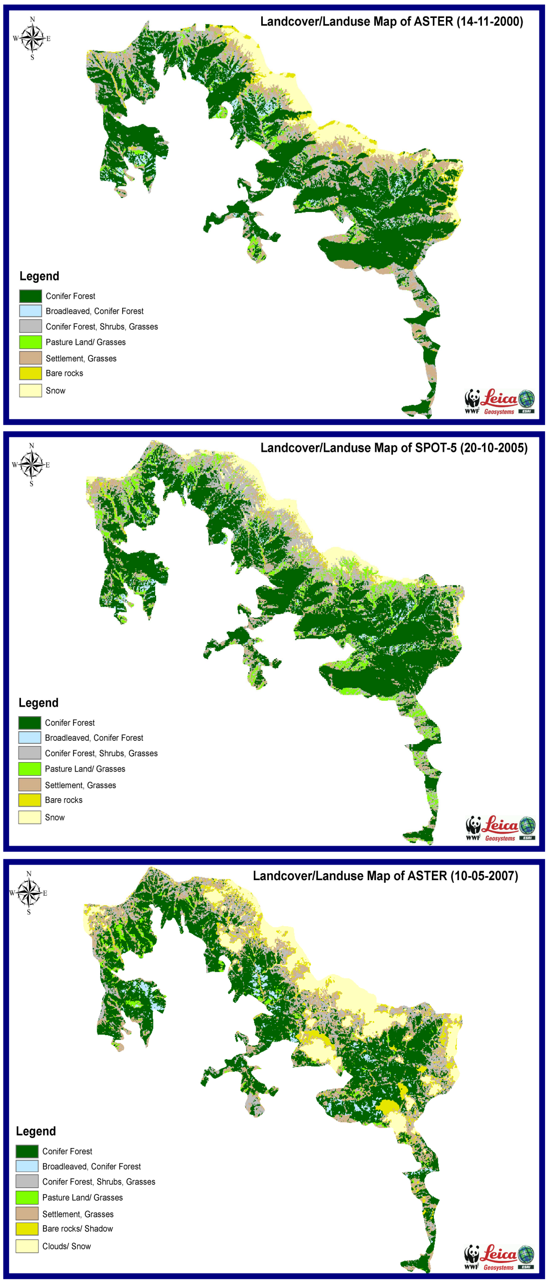

Figure 9: Output LCLU maps of MNP

V. REFERENCES

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