The Study of Change after Occurrence of Earthquake Induced Landslide Disaster in 2005 in Balakot, Pakistan

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ABSTRACT

The impacts of change ever have been remained great consideration after the occurrence of natural disasters so it might be detected the expected hazard, vulnerability and risk for taking mitigative measures in future. This study has been done based on utilizing the two different date's satellite imageries in that context. The satellite imageries have been interpreted using the different techniques of digital image processing such as supervised classification, and post classification etc. The maximum likelihood classification scheme, based on the field visit by various latitude and longitude coordinates and the photographs of the different features using GCP (Ground Control Positioning) receiver was used. The impacts of change have been studied using change detection technique. The change study notified the different variations in the land cover and the land use set up. It is believed that this type of study in connection of occurred change due to the natural disaster in region can be very useful for developing the landslide risk, hazard and the vulnerability models which would be benefited for the decision makers in future to redevelop the regions.

Key Words: **Change Detection, Supervised Classification, Maximum Likelihood Scheme, Ground Control Points, Landslide Risk Models.**

1. INTRODUCTION

The topography always changes due to the certain causes which are always invitations for the different school of thoughts to focus on it. The change impact is not only developed by the natural phenomena bust also it has severe negative human induced activities. The reduction in the extent of the vegetations in the tropical areas reflects the expected natural threat of the slope failures causing the human lives and the infrastructure losses in future [1]. The human induced activities such as cutting the forests, different changes in the built up environment are the great concern and considered as significant parameter for the triggering of the various slope forms to the low lands [2]. It is always suggested to focus on the impacts of change of the various forms of the topographic phenomena after happening of the natural disaster [3] because this approach is useful for the knowledge of geo-physical characteristics of the region [4]. The study of the scarcity of the vegetations

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and the forests lying in the category of land cover and the human set up comprising residential, official and the recreational infrastructure has always been enforced to study the different impacts of change on them after the occurrence of the natural disaster [5]. The role of the geographic extent of the study area and the historical records of natural phenomena also has been considered as important factor for studying the impacts of the change. This study can be useful to categorize the different landforms for the better use of the human purposes [6]. As the pattern of the various landforms vary because of the occurrence of the natural catastrophes e.g. landslides, tsunamis and river erosion while these types of natural calamities destroy the social and the economic setup up due to throwing into turmoil of natural impacts on the human preventions [7]. The exploitation of the natural environment is significant factor which develop natural disasters [8]. Space technology in the connection of various school of thoughts have played vital role for detecting changes using its various techniques [9]. Change study is performed by interpreting the digital data derived by the various satellites imageries [10] with different resolutions has remained great beneficial at the different scales The efficient data source for the various types of spatial revolution of landsat satellite in connection of GPS equipments and digital camera has been utilized for identifying the different levels of impacts o the different scales [11[. One of the technique called as classification of various landforms using digital data with different bands is utilized to interpret the different conditions of the forms of the land [12]. The change is known by the change detection method in the digital processing technique by using the satellite data of different periods of time [13] due to fluctuations in the happenings of slope forms in the geophysical and geopotent situations. The USGS has produced the standard chart of scheme of the land cover and land use classes into various classes so as if it could be utilized for detecting the change of different time periods [14]. The different schemes utilize such approach by vesting the field data to justify the different objects of the interest [15].

In this research paper, it has been aimed to study the impacts of change after occurrence of earthquake induced landslide disaster in 8th October 2005 in city of Balakot lying in the north territory of Pakistan which was totally destroyed in terms of human lives and infrastructure. It is believed that this type of change study will prove useful for the decision makers to rehabilitate the region for avoiding such types of landslide hazard threat in future.

2. METHODLOGY

2.1 Study Area

The case study of this research is Balakot as shown in Fig. 1, one of the northern cities of Pakistan which was destroyed in 8th October 2005 as shown in Fig. 1. Balakot surrounds Hazara-Kashmir Syntaxis, sketching the margin of MBT (Main Boundary Thrust). Balakot is covered with mountains with the elevations about 500-5000 (asl). Kunhar river flows with the intensity of about 75 m^3/s [16] from the center of city of Balakot. The temperature of city remains at maximum 16-2°C and in summer 38°C getting the 1300-1600 mm precipitation in a year. The fault line crosses from the center of the city so Balakot is very seismic prone regions having the threats of earthquake any time by creating the risk of slope failures in the region [17].

2.2 Data Utilized

The following Table 1 shows the used data in this research as below:

Landsat 5 TM data of 2005 has been utilized as pre-occurrence disaster data, which has been shown in the Fig. 2.

Landsat 5 TM data of 2009 has been used as post-occurrence disaster data, which has been shown in the Fig. 3.

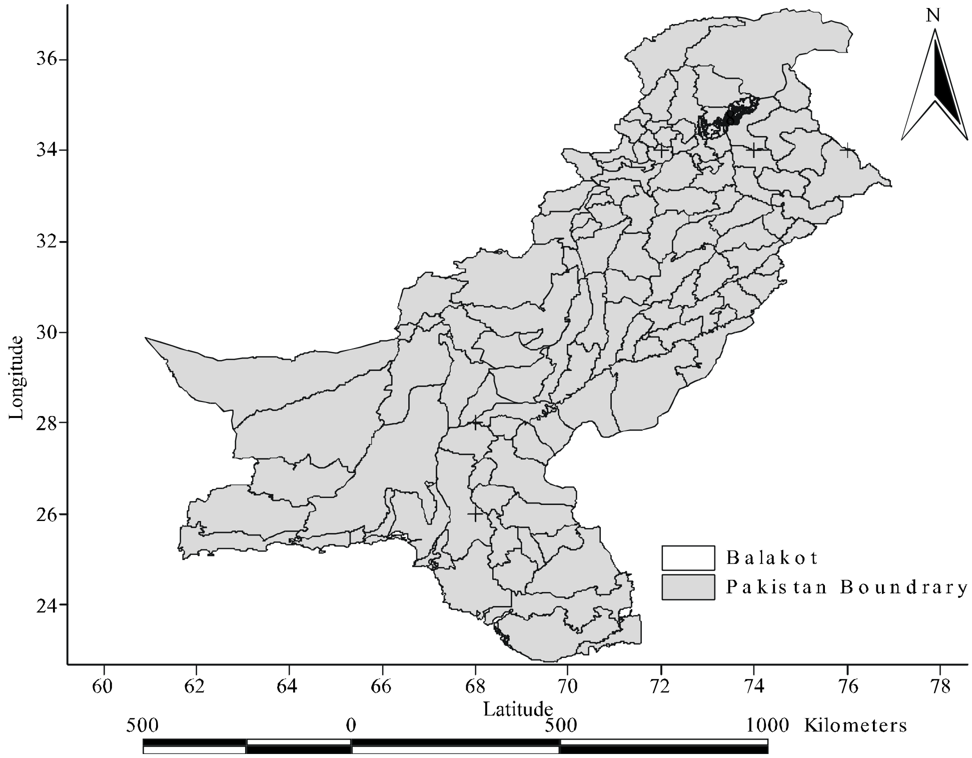

FIG. 1. PAKISTAN MAP SHOWING BALAKOT BOUNDARY

TABLE 1. DATA USED

No.	Name	Bands Used	Year	Resolution	Source
1.	Landsat 5TM	4,5,7	2005	30m	GLCF, ESDI
2.	Landsat 5TM	4,5,7	2009	30m	GLOVIS
3.	Aerial Photograph	-	2007	-	-
4.	Aerial Photograph	-	2008	-	-
5.	Top Map	-	-	1:250,000	-
7.	Tourist Map	-	-	-	-

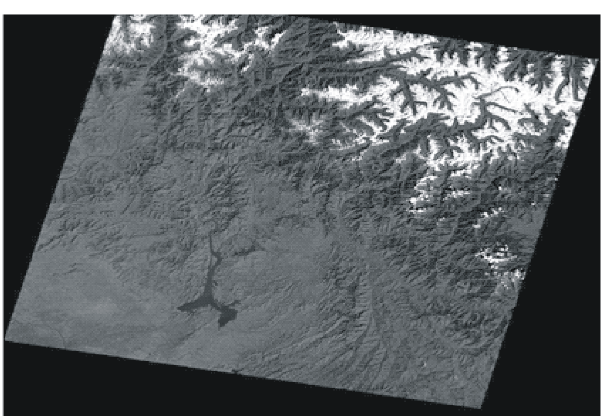

FIG. 2. LANDSAT 5 TM DATA OF 2005

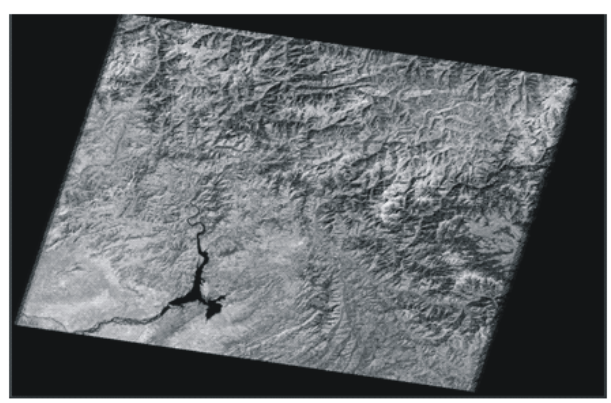

FIG. 3. LANDSAT 5 TM DATA OF 2009

2.3 Methodology

The following procedures have been used in the research:

2.3.1 Subsetting the Satellite Data

The satellite data of pre-disaster period was resized into required coordinates which are; Latitude (N) as; 34.3300 and 34.5500 while the Longitude (E) are as 73.2100 and 73.3500, of Balakot region using the sub setting technique (Figs. 4-5).

The satellite data of post disaster period was subsetted the subsetting technique with the same coordinates of pre-occurred disaster satellite data, with projection UTM, zone 43.

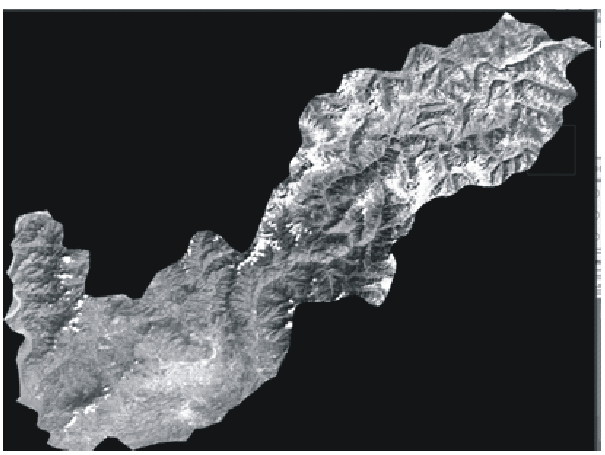

FIG. 4. SUBSETTED BALAKOT AREA OF PRE-DISASTER

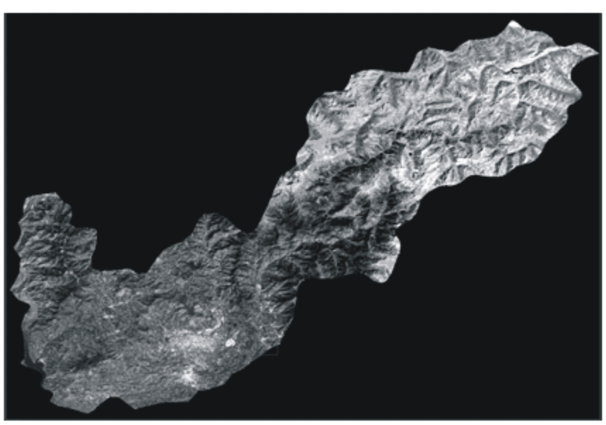

FIG. 5. SUBSETTED BALAKOT AREA OF POST-DISASTER

2.3.2 Classifying the Two Images

After subsetting, the both images were classified using the supervised classification scheme including its sub scheme as maximum likelihood using combination based on the field visit collected data with their observed coordinates of the different features of the area called as GCPs (Ground Control Points) using GPS receiver. Satellite image before the occurrence disaster was classified as shown in Fig. 6. The various collected GCPs have been mentioned in Appendix-1.

The classifying image of 2005 was et into six classes such as marshy land, built up, vegetated mountain, steep hills, and forest and water bodies. The residential locations were sorted at the very lowland of the study area along the banks of river Catchment locations showed the very high density alarming the slope failures for future. The satellite imagery of 2009 was also classified into six classes such as landslides, marshy land, vegetation, steep hills, forest and water bodies as shown in Fig. 7.

Some of the slope failures were along the 0-2000m asl while majority of landslides were in the 0-2000m elevation at asl along the river, streams and the road lines. Vegetations and the forests were observed in the elevation of 4000-5000m asl. The overall accuracy of producer and User of both satellite data after classification have been mentioned in Table 2.

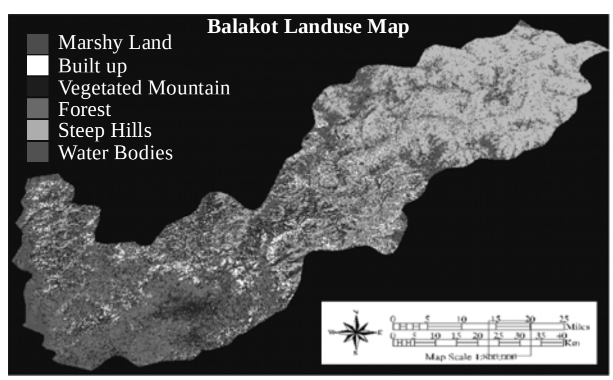

FIG. 6. CLASSIDED IMAGE OF 2005

The accuracy of the producer and the user after the classification of the different categories of both images has been mentioned as shown in Table 3.

3. RESULTS

3.1 Change Detection Model

The change detection technique was applied after classifying the both images and the outcome was achieved as mentioned in Fig. 8.

The change model was generated into three categories such as disappeared built up, deforestation and not changes s shown in Fig. 8. The accuracy of change detection model has been shown in Table 4.

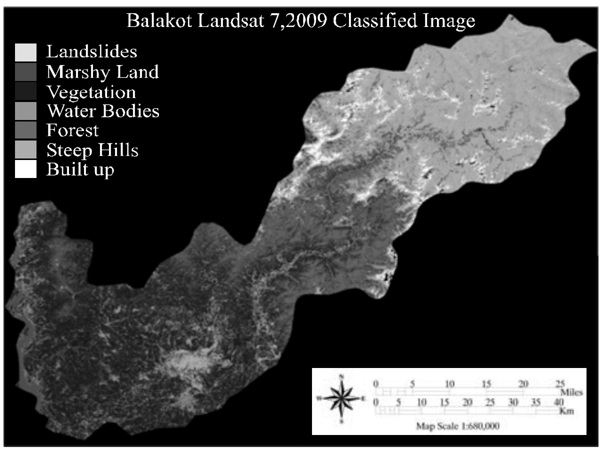

FIG. 7. CLASSIDED IMAGE 2 OF BALAKOT DATED 16TH SEPTEMBER, 2009

TABLE 2. THE ACCURACY OF USER AND PRODCUER OF TWO DIFFERENT SATELLITE IMAGES AFTER CLASSIFICATION

Classified Images	Over All Accuracy	Kappa Statitics
Landsaat 5TM, 2000	76.38	0.712
Landssat 5TM, 2009	79.500	0.742

The accuracy of producer and the user of the change detection model of the different classes have been described in Table 5.

This change model notified that majority of the area has been change due to destruction of the human built up, vegetations and the forests while the above 30% area has got no any remarkable change because of the occurred landslide failures in Balakot region.

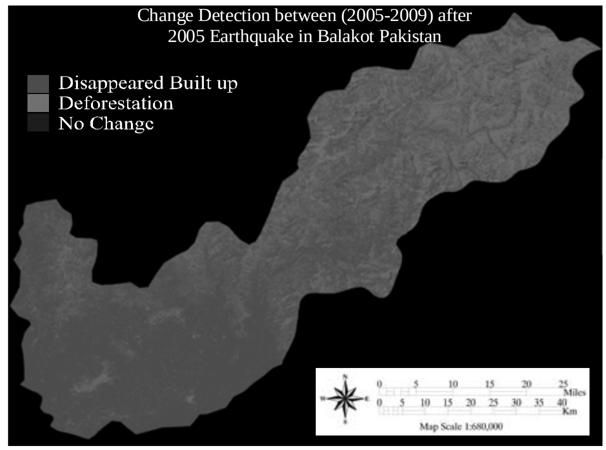

FIG. 8. CHANGE DETCETION MODEL

TABLE 4. ACCURACY ASSESSMENT OF CHANGE DETECTION MODEL

Map	Over All Accuracy	Kappa Statstitics
Change Map	92.00 (%)	0.086 (%)

TABLE 5. PRODUCER'S AND USER'S ACCURACIES OF FOR CHANGE MODEL OF VARIOUS CATEGORIES

Classes	Producer's Accuracy	User's Accuracy	Kappa Statitics
Unchanged Area	92.85	86.87	0.8212
Disappeared Built up	60..00	75.s00	0.7222
Defroestattion	85.75	75.60	0.7418

TABLE 3. ACCURACY OF PRODUCER AND USER OF CHANGE MODEL OF CARIOUS CLASSIFIED REGIONS

Classes	Producer's Accuracy		User's Accuracy		Kappa Statistics	
	2005	2009	2005	2009	2005	2009
Landslides	72.73	81.83	67.78	76.23	0.6324	0.7274
Marshy Land	90.91	100.00	77.92	100.00	0.7515	1.000
Water Bodies	85.77	75.00	80.23	80.00	0.778	0.773
Forest	63.51	67.68	71.43	75.00	0.679	0.724
Steep Hills	69.23	75.00	75.00	66.67	0.719	0.645
Built Up	89.90	99.89	78.85	9.89	0.774	0.993

APPENDIX-A: GCPS DATA

No.	Northing	Easting	No.	Northing	Easting
1.	N 34 37 27 4	E73 32 068 00	35.	N 34 26 55 23	E 73 26 16 16
2.	N 34 37 48 47	E73 29 51 58	36.	N 34 26 52 12	E 73 26 13 30
3.	N 34 39 32 24	E73 29 18 11	37.	N 34 27 23 56	E 73 25 32 42
4.	N 34 39 38 35	E73 28 37 26	38.	N 34 27 27 14	E 73 28 15 14
5.	N 34 31 42 18	E 73 28 17 6	39.	N 34 27 26 24	E 73 29 6 22
6.	N 34 21 55 5	E 73 28 2 42	40.	N 34 27 25 5	E 73 29 11 24
7.	N 34 21 53 28	E 73 22 28 12	41.	N 34 27 13 55	E 73 29 6 54
8.	N 34 21 58 8	E 73 23 7 59	42.	N 34 26 33 58	E 73 29 44 35
9.	N 34 25 6 36	E 73 23 31 37	43.	N 34 25 6 40	E 73 29 54 54
10.	N 34 21 59 10	E 73 24 51 32	44.	N 34 20 14 17	E 73 30 44 10
11.	N 34 21 54 4	E 73 25 13 23	45.	N 34 20 13 41	E 73 31 9 43
12.	N 34 21 43 52	E 73 25 39 18	46.	N 34 13 15 14	E 73 32 37 8
13.	N 34 21 46 41	E 73 27 8 2	47.	N 34 11 4 44	E 73 33 53 24
14.	N 34 21 51 50	E 73 27 30 22	48.	N 34 10 56 53	E 73 33 56 31
15.	N 34 22 2 10	E 73 20 50 46	49.	N 34 10 52 19	E 73 34 49 8
16.	N 34 21 37 8	E 73 30 30 25	50.	N 34 10 49 12	E 73 35 9 40
17.	N 34 21 53 10	E 73 30 24 0	51.	N 34 10 15 0	E 73 35 33 54
18.	N 34 23 5 42	E 73 30 21 14	52.	N 34 10 30 4	E 73 37 22 30
19.	N 34 23 9 43	E 73 41 58 59	53.	N 34 10 34 37	E 73 41 58 59
20.	N 34 23 12 47	E 73 30 0 4	54.	N 34 10 16 30	E 73 26 55 19
21.	N 34 23 21 50	E 73 30 8 6	55.	N 34 9 25 19	E 73 27 6 50
22.	N 34 23 26 35	E 73 30 32 49	56.	N 34 7 30 47	E 73 37 20 53
23.	N 34 23 40 34	E 73 29 51 50	57.	N 34 6 34 19	E 73 40 56 38
24.	N 34 23 54 50	E 73 29 35 31	58.	N 34 37 27 4	E 73 41 3 32
25.	N 34 24 0 4	E 73 29 19 55	59.	N 34 37 48 47	E 73 41 36 0
26.	N 34 24 4 23	E 73 29 18 32	60.	N 34 39 32 24	E 73 41 36 50
27.	N 34 24 26 46	E 73 28 40 8	61.	N 34 39 38 35	E 73 44 52 16
28.	N 34 24 20 2	E 73 28 39 22	62.	N 34 31 42 18	E 73 45 56 20
29.	N 34 24 43 37	E 73 27 27 22	63.	N 34 21 55 5	E 73 46 3 32
30.	N 34 24 47 56	E 73 27 12 0	64.	N 34 21 53 28	E 73 46 58 12
31.	N 34 25 0 40	E 73 27 4	65.	N 34 21 58 8	E 73 49 48 22
32.	N 34 26 15 47	E 73 26 43 41	66.	N 34 25 6 36	E 73 52 1 16
33.	N 34 26 22 55	E 73 26 34 48	67.	N 34 21 59 10	E 73 53 16 37
34.	N 34 26 41 20	E 73 26 20 13	-	-	-

Source: Peduzzi, P., "Natural Hazards and Earth System Sciences Landslides and Vegetation Cover in the 2005 North Pakistan Earthquake: A GIS and Statistical Quantitative Approach", Natural Hazards Earth System Society, Volume 10, pp. 623-640, Copernicus Publications Italy, 2010 [8]

5. DISCUSSIONS

This type of research study warns the decision makers to re-ponder on the situation of the affected areas due to the remarkable occurred changes after the occurrence of the landslide disaster. The significant variation in the human residential areas enforce to the high authorities to redevelop and reconstruct such regions in that way, that these areas might not be affected in future again from such phenomena . The disappearance of the vegetations and the forests in the affected area after the occurred disaster also teach the lesson that, they play the role to protect the mountains by pore water pressure unless rocks become fragile to fall due to their weak strength during the resistance of internal strength of the soil.

6. CONCLUSION

It was observed that the residential and built up system was entirely disappeared along the river banks and the low elevation while the land cover was also vanished due to the human induced activities by deforestation in the area. It was also noted that even then there was not any significant change in the river, streams and the catchment locations because those were fallen down from high to low elevation creating the damages.

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REFERENCES

[1] Van-Westen, C.J., Castellanos, E., and Kuriakose, S.L., "Spatial Data for Landslide Susceptibility, Hazard, and Vulnerability Assessment: An Overview", Engineering Geology, Volume 102, pp. 112-131, Elsevier Publishers Netherlands, 2008

[2] Claessens, L., Schoorl, J.M., and Veldkamp A., "Modelling the Location of Shallow Landslides and their Effects on Landscape Dynamics in Large Watersheds: An Application for Northern New Zealand", Geomorphology, Volume 87, pp. 16-27, Elsevier Publishers Germany, 2007.

[3] Soomro, A.S., "Landslide Risk Analysis Modeling Using Digital Image Processing (DIP) and Geographical Information Systems (GIS) Techniques in Balakot, Pakistan", Ph.D. Thesis, Department of Industrial Engineering & Management, Mehran University of Engineering & Technology, Jamshoro, Pakistan, 2011.

[4] Saba, S.B., Meijde, V.D.M., Werff, H.V.D., "Spatiotemporal Landslide Detection for the 2005 Kashmir Earthquake Region", Geomorphology, Volume 124, pp. 17-25, Elsevier Publishers Netherlands, 2010.

[5] Shalaby, A., and Tateishi, R., "Remote Sensing and GIS for Mapping and Monitoring Land Cover and Land-Use Changes in the Northwestern Coastal Zone of Egypt", Applied Geography, Volume 27, No. 1, pp. 28-41, Elsevier Publisher, USA, 2007.

[6] Bhattacharya, A., "Geologic and Geomorphic Controls in Land Use Patterns: Examples Using Remote Sensing Techniques", Journal of the Indian Society of Remote Sensing , Volume 11, No. 3, Dehradun, India, 1983.

[7] Irasema, A., "Geomorphology, Natural Hazards, Vulnerability and Prevention of Natural Disasters in Developing Countries", Geomorphology, Volume 47, pp. 107-124, Elsevier Publishers Netherlands, 2002.

[8] Peduzzi, P., "Natural Hazards and Earth System Sciences Landslides and Vegetation Cover in the 2005 North Pakistan Earthquake: A GIS and Statistical Quantitative Approach", Natural Hazards Earth System Society, Volume 10, pp. 623-640, Copernicus Publications Italy, 2010.

[9] Samaniego, L., and Schulz K., "Supervised Classification of Agricultural Land Cover Using a Modified k-NN Technique (MNN) and Landsat Remote Sensing Imagery", Remote Sensing, Volume 1, pp. 875-895, Switzerland, 2001.

[10] Vanwesten, C.J., "Geo-Information Tools for Landslide Risk Assessment: An Overview of Recent Developments", Lacerda, W.A., Ehrlich, M., Fontoura, S.A.B., and Sayao, A.S.F. (Editors), "Landslides: Evaluation and Stabilization, Balkema, Taylor & Francis Group, pp. 39-56, London, 2004.

[11] Yüksel, A., Akay, A.E., and Gundogan, R., "Using ASTER Imagery in Land Use/Cover Classification of Eastern Mediterranean Landscapes According to CORINE Land Cover Project", Journal of Sensors, Volume 8, pp. 1237-1251, USA, 2008.

[12] Xu, B., and Gong P., "Land-Use/Land-Cover Classification with Multispectral and Hyper spectral EO-1 Data", Photogrammetric Engineering & Remote Sensing, Volume 73, No. 8, pp. 955-965, Publishers, American Society for Photogrammetric and Remote Sensing, USA, 2007.

[13] Khyber, Q., "Effects of the Muzzaffarabad Earthquake 2005-Detection and Quantification of Changes in Land Cover/Land Use", M.Sc. Thesis, Geoinformatics, TRITA-GIT EX 09-014, Division of Geoinformatics, Royal Institute of Technology (KTH), Stockholm, Sweden, 2009.

[14] Bing, X., and Peng, G., "Land-Use/Land-Cover Classification with Multispectral and Hyperspectral EO-1 Data", Photogrammetric Engineering & Remote Sensing, Volume 73, No. 8, pp. 955-965, USA, 2007.

[15] Deren, L., Kaichang, D.I., Deyi, L.I., "Land Use Classification of Remote Sensing Image with GIS Data Based on Spatial Data Mining Techniques, International Archives of Photogrammetry and Remote Sensing, Volume XXXIII, Part-B3, pp. 238-245, Amsterdam, 2000.

[16] Kamp, U., Growley, B.J., Khattak, G..A., Owen, L.A., "GIS-Based Landslide Susceptibility Mapping for the 2005 Kashmir Earthquake Region", Geomorphology, Volume 101, No. 4, pp. 631-642, Elsevier Publishers Netherlands, 2008.

[17] Zaré, M., Karimi, P.S., and Mona, L., "An Investigation on Balakot, Muzaffarabad (Pakistan) Earthquake, 8 October 2005, Mw 7.6, Geological Aspects and Intensity Distribution", Journal of Seismology, Volume 13, pp. 327-337, Springer Publishers, Germany, 2009.

[18] Owen, L.A., Kamp, U., Khattak, G.A., Harp, E.L., Keefer, D.K., and Bauer, M.A., "Landslides Triggered by the 8 October 2005 Kashmir Earthquake", Geomorphology, Volume 94, pp. 1-9, Elsevier Publishers Netherlands, 2008.