

EFFECT OF EARTHQUAKE ON FOREST VEGETATION OF MUZAFFARABAD AND BALAKOT AREAS

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Abstract

A severe earthquake of magnitude 7.6 on richter scale hit Pakistan on October 8, 2005. Muzaffarabad and Balakot were the worst hit areas located in the northern parts of the country. The earthquake had real impacts on human life and property of these areas. Apart from this, the forestry resources of these areas, which are eminent for their watershed values and the biodiversity they abode, were also affected. It was, therefore, deemed necessary to assess the impacts of earthquake on forest vegetation of these areas. As a result of which, the current study was conducted. To study the forest trees damaged in the study area, 5 km interval plots were laid along the traversed road in both the areas. The results revealed that Muzaffarabad was inflicted with most of the damages to forest trees in comparison to Balakot. Similarly, damage to under storey vegetation was also greater in the former. It was also found that mixed crop had less damages compared to pure crop. It was also revealing that the proximity of epicenter of the earthquake has not played any significant role in terms of imparting forest trees damages. Based on the findings, it was suggested that reforestation/afforestation activities should be conducted in degraded areas. Also, appropriate scientific grazing systems should be proposed along with alternate energy resources for the local inhabitants.

INTRODUCTION:

Earthquake occurred in Pakistan on October 8, 2005. The intensity of this earthquake was recorded as 7.6 on Richter Scale (IUCN, 2006). Epicenter of this earthquake was determined as 100 km northeast from the capital city, Islamabad (ADB, 2005). This event had resulted in dreadful impact on human lives and society. The North West Frontier Province (NWFP) and Azad Jammu & Kashmir (AJ & K), the two regions, were the most severely affected due to the earthquake. Within these two regions of NWFP and AJ & K, Balakot and Muzaffarabad were the two worst earthquake hit areas. There have been

35,803 human lives lost with 23,138 injuries and 125,277 houses destroyed in Muzaffarabad alone as a result of the earthquake (ERRA a, 2007). Similarly, 200,000 people have been affected due to the earthquake in Balakot Tehsil (HC, unpublished).

Apart from other damages, inflicted by the earthquake, there were fears of its adverse affects on forest vegetation as well. This study was therefore conducted to assess the impact of earthquake on forest vegetation of Muzaffarabad and Balakot. The objectives of the study were 1) to assess damage to forest vegetation after earthquake in Muzaffarabad and Balakot areas. 2)

To assess the earthquake damage to the under storey vegetation of natural forests in Muzaffarabad and Balakot.

Study Area:

Muzaffarabad is the capital of Azad Jammu & Kashmir (AJ & K). It occupies an area of 6117 square kilometer. It lies between 34.24°N latitude and 73.22° E longitude. The population is 0.746 million (ERRA b, 2007). The terrain is hilly and mountainous. The climate is sub tropical highland type. The average annual rainfall ranges from 1000 to 1300 mm and the mean maximum temperature ranges from 20 ° C to 32 ° C, whereas, mean minimum temperature ranges from 4 ° C to 7 ° C (GOP, 2004).

The forests form 59 % of the Muzaffarabad Region (ERRA b, 2007). The forest types are Dry Sub Tropical Scrub Forests and Sub Tropical Pine Forests (Termizi *et al.* 2001). Some major vegetation of these forests includes *Olea ferruginea*, *Acacia modesta*, *Dalbergia sissoo*, *Pistacia integerrima*, *Pinus roxburghii*, *Xanthoxylum alatum*, *Punica granatum*, *Ficus palmata* and *Dodonea viscosa*.

Balakot is situated in North West Frontier Province (NWFP), lying between 34° 15' and 34° 50' North latitude and 73° 40' East longitude. The area has an estimated population of 250000 (HC, unpublished). The topography is undulated, rugged and mountainous. Generally, the climate

is moist temperate. Snowfall usually occurs between December and March. The drought is noticed from April to June and September to middle of December.

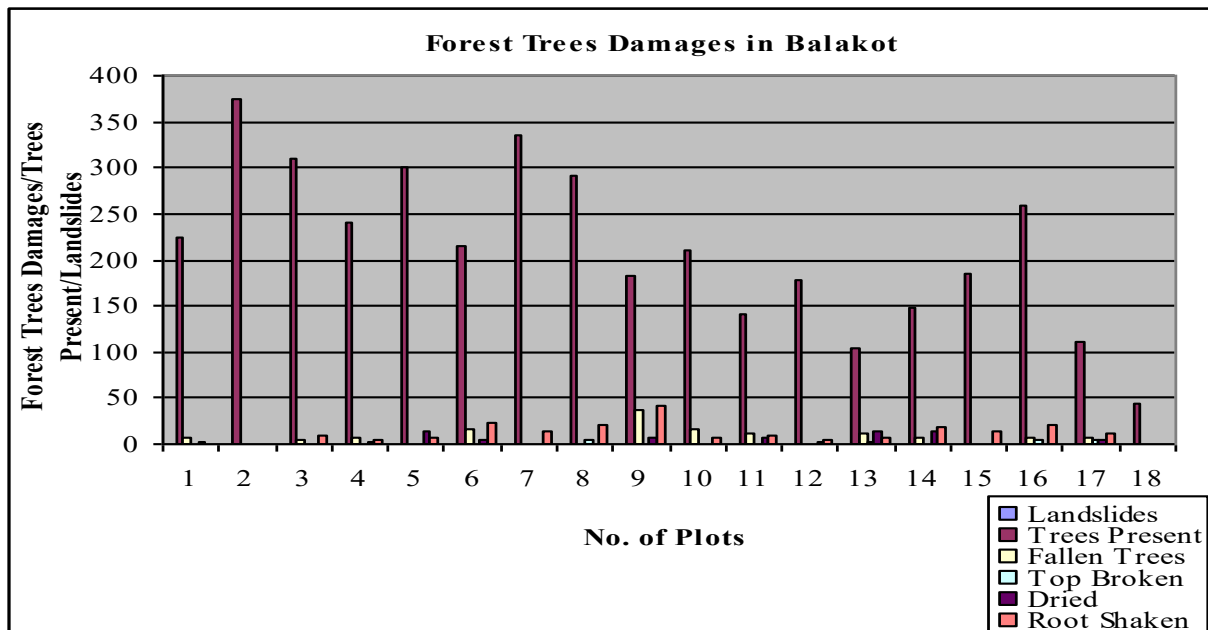
The forests in Balakot are classified as Sub Tropical Chir Pine Forests, Sub Tropical Moist Forests and Temperate Forests. The major vegetation includes *Abies pindrow*, *Picea smithiana*, *Cedrus deodara*, *Mallotus philippinesis*, *Woodfordia floribunda*, *Glochidion velatum*, *Indigofera pulchella*, *Myrsine africana*, *Berberis Lycium*, *Colebrookea oppositifolia*, *Zizyphus oxypholla*, *Pinus wallichiana*, *Quercus incana*, *Quercus dilatata*, *Alnus nitida* and *Berberis*, *Cratagus*. etc.

Methods:

For forest trees damage assessment, plots were laid along the traversed road at an interval of 5 km both in Muzaffarabad and Balakot areas. The size of the plot was kept as 1 ha. The accessibility along roads was also considered while laying plots. The damages to forest trees were categorized as fallen, top broken, dried and root shaken. The parameters recorded for forest trees damage assessment were as follow; 1) Total number of trees/plot, 2) Total number of trees fallen/plot, 3) Total number of trees with top broken/plot, 4) Total number of trees dried/plot, 5) Total number of trees with root shaken/plot, 6) Number of landslides / plot, 7) Area of each landslide / plot

The damage was assessed in percentage by using the following formula;

Percentage (%) Damage = $\frac{\text{No. of trees damaged}}{\text{Total number of trees}} \times 100$



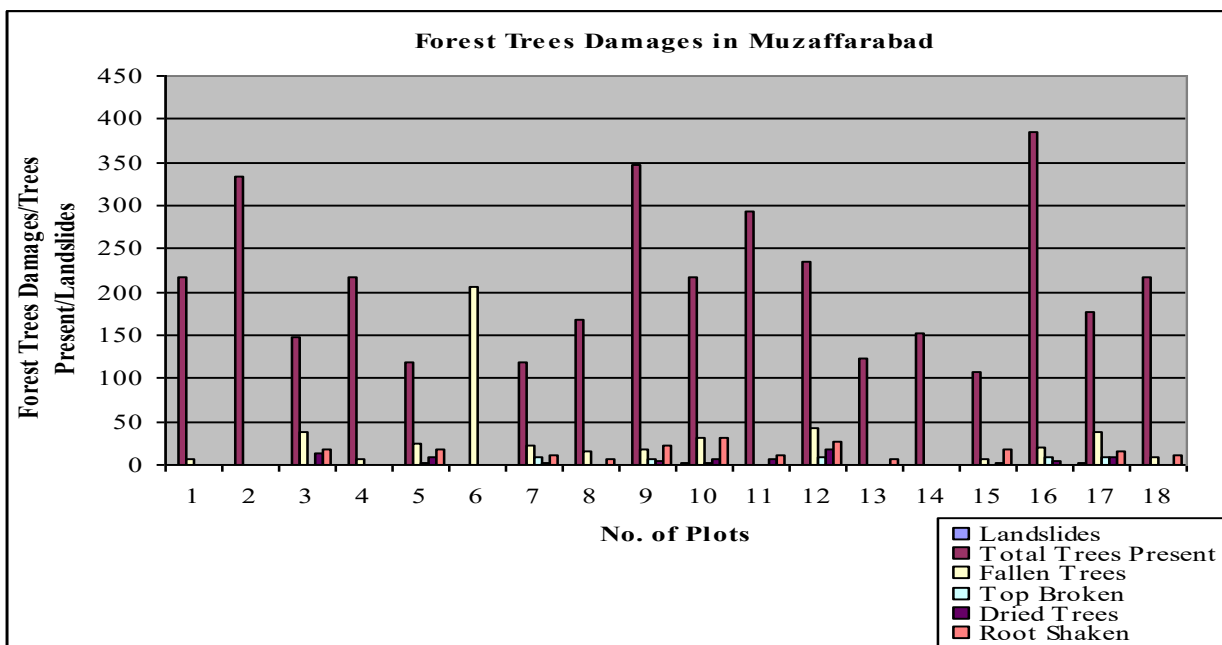
Total no. of trees/plot

For computing damages to under storey vegetation, 10 x 10m size quadrates were laid in already placed plots for assessing forest trees damages. The following parameters were assessed for the purpose; 1) Species composition, 2)

Frequency distribution percentage, 3) Cover composition percentage, 4) Landslide cover percentage.

The formula used for assessing the cover composition percentage was as follow;

Cover % age: $\frac{\text{Total cover of individual plant}}{\text{Total area of the transect}} \times 100$



Results:

Comparative Damages to Forest Vegetation in Muzaffarabad and Balakot Areas:

Damage to Forest Trees:

As the graph depicts, 36 were the highest number of fallen trees, found in plot 9. There were 5 top broken trees, the highest, in plot 17. Similarly, 13 was the highest number in case of dried trees, recorded in plot 5, plot 13 and plot 14. The highest number of root shaken trees, 41, was observed in plot 9. There were overall 3850 trees present in the sampled areas and the 11 landslides were recorded.

As depicted in the above graph, plot 6 had the most number of fallen trees, which were 206. Similarly, plot 12 had the highest number of top broken and dried trees with 10 (top broken) and 18 (dried) respectively. The plot 10 had the most number of root shaken trees; the number was recorded as 34. The overall trees present in sampled plots were 3575 and 14 landslides were

observed.

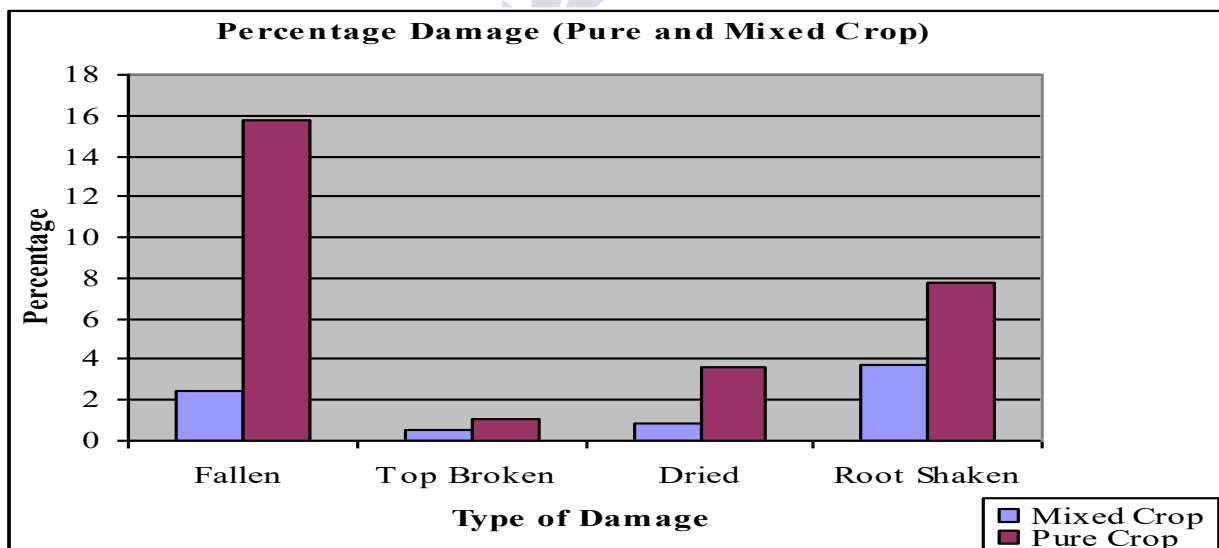
Landslides and Forest Vegetation:

As shown in Table 1, 25 total landslides were recorded in Muzaffarabad and Balakot areas. The average size per plot was 1196 m².

Landslides and Crop Types (Mixed and Pure):**Percentage Damage to Pure and Mixed Crop:**

Landslides, Percent landslide Area/Plot, Average No. of Trees Present/Plot after Earthquake

It is clear from Table 2 that the percent landslide area/plot in mixed crop was 8 while it was 26 in pure crop. Similarly, there were 9 landslides recorded in mixed crop whereas 16 landslides were observed in pure crop. The tree species encountered in mixed crop were *Pinus roxburghii*, *Ailanthus altissima*, *Olea furruginea*, *Broussonetia papyfera*, *Populus alba*, *Pyrus pashia*, *Quercus incana*, *Pinus wallichiana* and *Cedrus deodara*. In case of pure crop, the only tree was *Pinus roxburghii*.

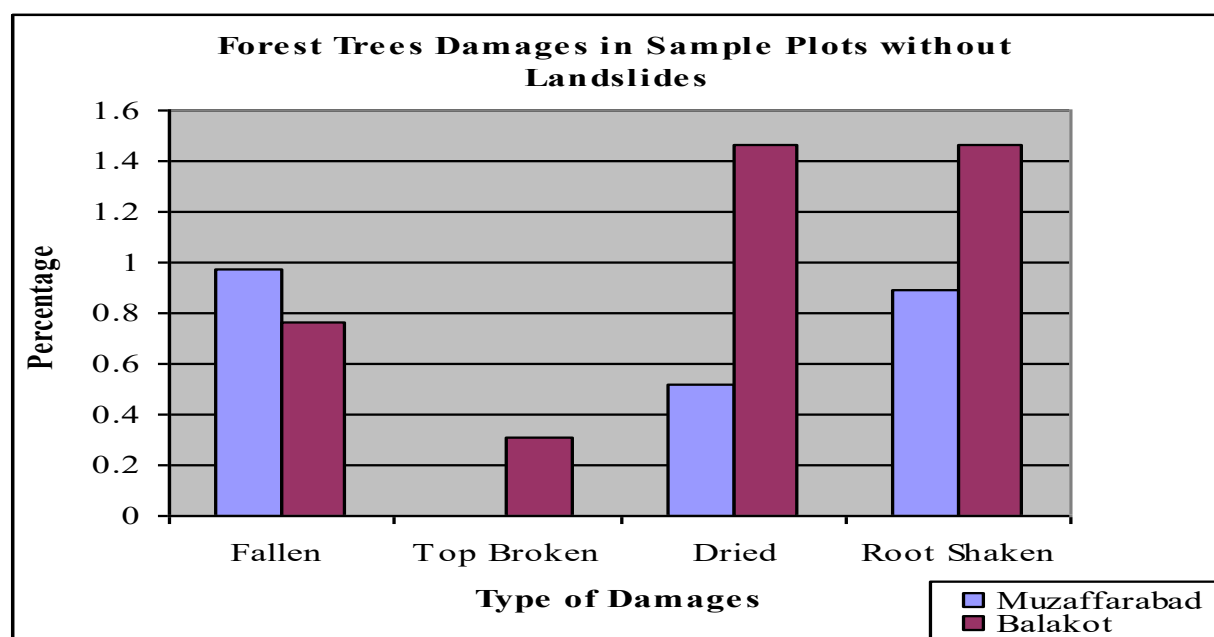


No. of plots	No. of land slides	Trees present		Area of landslides in m ²		Fallen trees		Top broken trees		Dried trees		Root shaken trees	
		Tot al.	Avg /plo t.	Tota l	Avg./plot	Tota l	Avg./plot	Total	Avg./plot	Tota l	Avg./plot	Tot al	Avg./plot
36	25	7425	206	43074	1196	614	17	58	1.61	152	4.2	407	11.3

The highest percentage of damage was in the form of fallen trees, which was recorded in mixed crop, as also depicted in the graph. The other damages followed in the form of root shaken,

dried and top broken. All these damages were again higher in mixed crops as compared to pure crop.

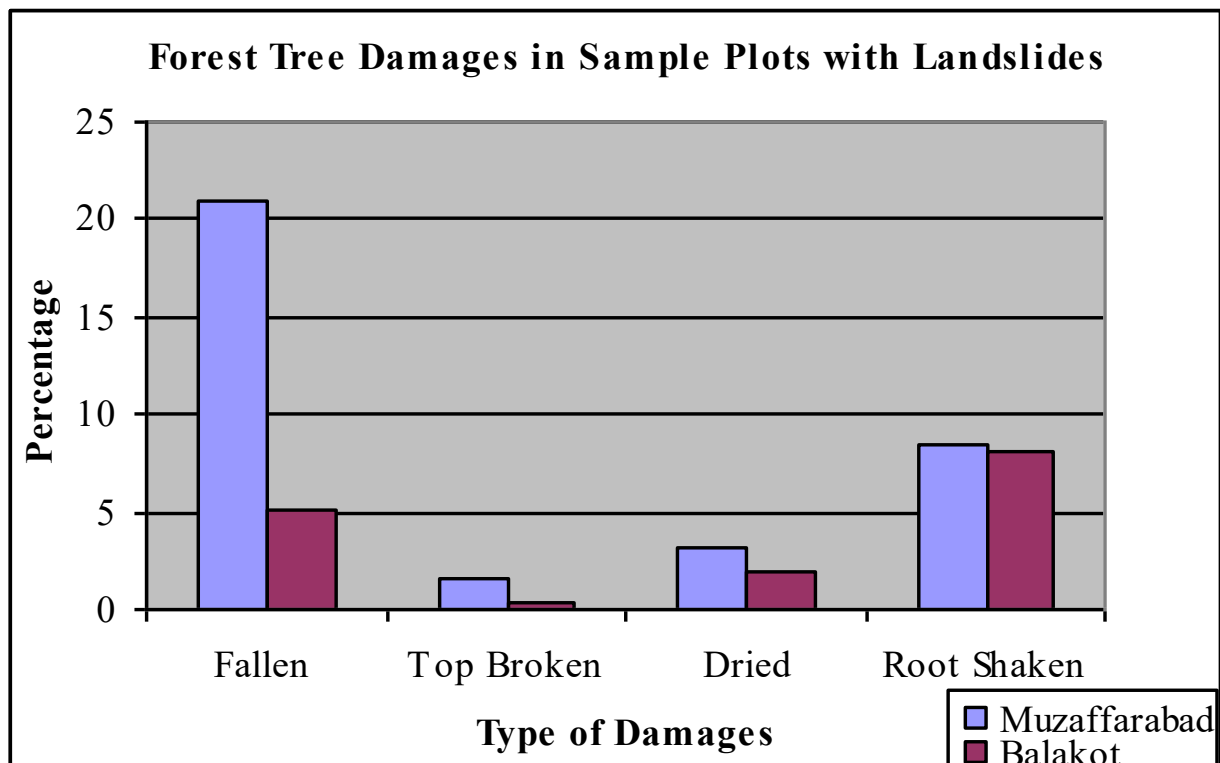
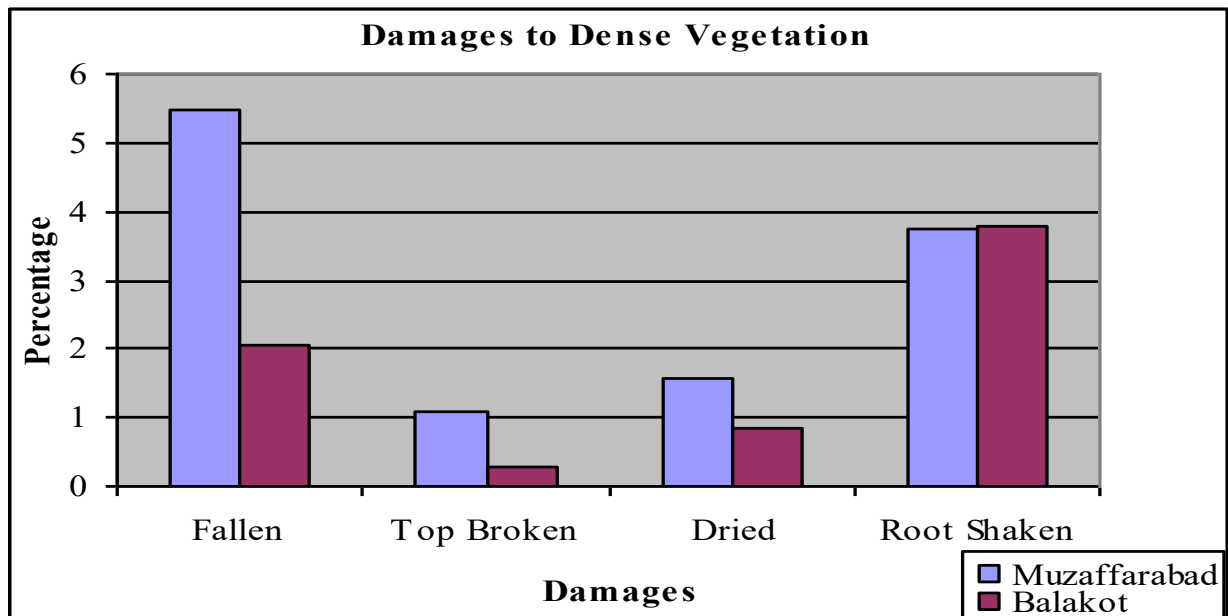
Crop type	Sample plots	No. of Landslides	Percent Landslide Area/ plot.	Average No. of trees present /plot after earthquake.
Mixed crop	19	9	8	223 (54%)
Pure crop	17	16	26	187 (45%)
Total	36	25	34	410

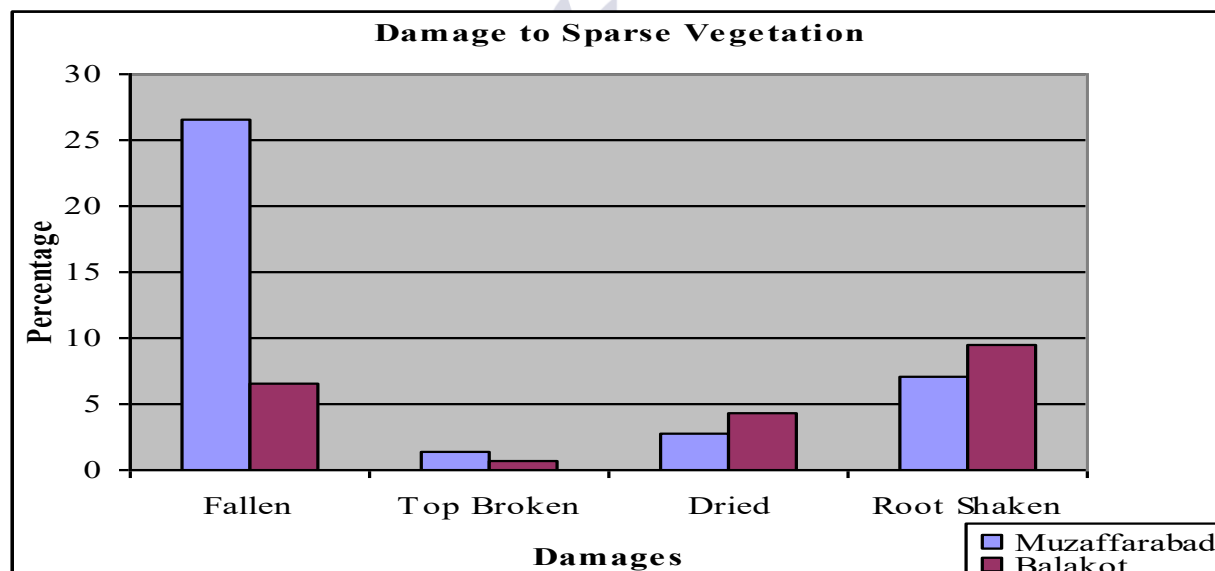
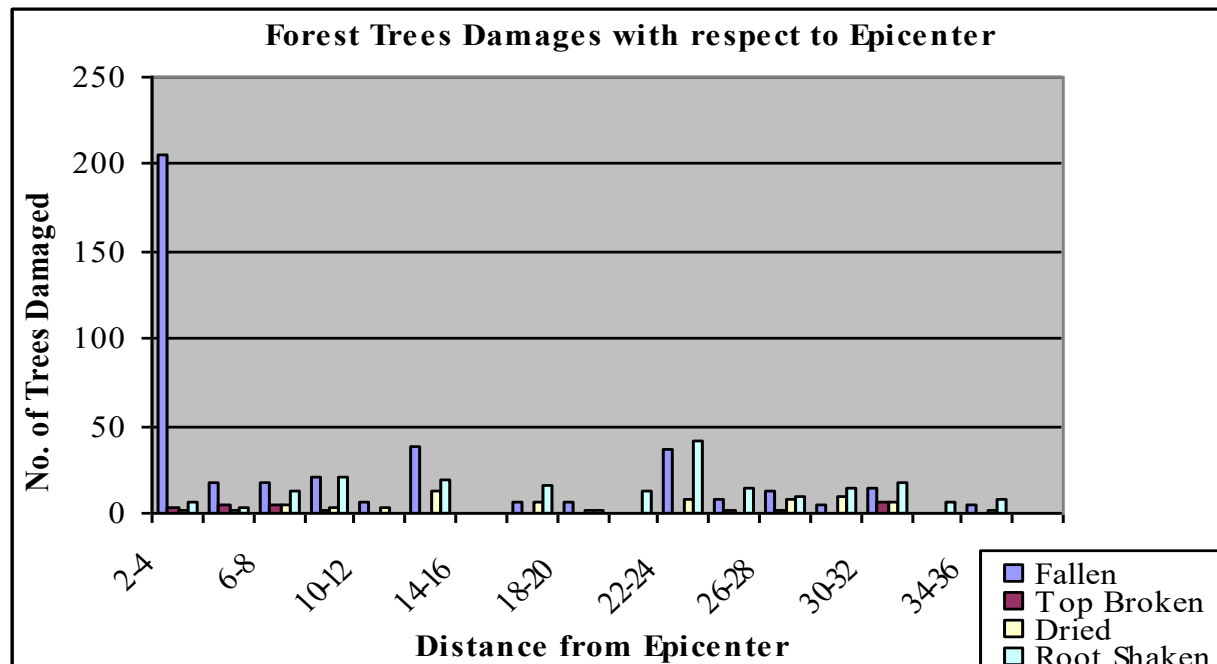


Forest Damages in Landsliding Sample Plots Versus Non-Landsliding Sample Plots:

The damages in percentage in sample plots without landslides were recorded as 0.97 (Fallen), 0 (Top Broken), 0.52 (Dried) and 0.89 (Root Shaken) in Muzaffarabad and 0.76 (Fallen), 0.31 (Top Broken), 1.46 (Dried), 1.46 (Root Shaken) in Balakot respectively. There were an overall 13 sample plots which were found without

landslides. Similarly, the percentage damages to forest trees in plots with landslides were recorded as 12 (Fallen), 1.67 (Top Broken), 3.1 (Dried), and 8.4 (Root Shaken) in Muzaffarabad. And, 5.1 (Fallen), 0.4 (Top Broken), 1.9 (Dried), 8.1 (Root Shaken) percentage damages in Balakot. Similarly, there were over all 23 plots with landslides





Damage with respect to epicenter:

The epicenter of the earthquake was 19 km northeast of Muzaffarabad (34° 29' 35" N and 73° 37' 44" E). The results have shown that there has not been any considerable effect of distance from the epicenter. As the damages to forest trees were noticed almost at all distances with reference to epicenter.

Dense and Sparse Vegetation:

Sample Plots having Dense Vegetation;

The plots having more than 200 trees were categorized as dense vegetation plots. There were 9 and 10 dense vegetation plots in Muzaffarabad and Balakot respectively. To record the most number of damages, the dense vegetation plots in Muzaffarabad had the 135 fallen trees whereas dense vegetation plots in Balakot had 106 root

shaken trees. The percentages of these damages, as also depicted by the graph, were 5.47 (Fallen), 1.09 (Top Broken), 1.58 (Dried) and 3.73 (Root Shaken) in Muzaffarabad, and 2.06 (Fallen), 0.28 (Top Broken), 0.83 (Dried) and 3.8 (Root Shaken) in Balakot.

Sample Plots having Sparse Cover;

Similarly, the plots having less than 200 trees were categorized as sparse vegetation plots. There were 9 of such plots in Muzaffarabad and Balakot had 8 of these plots. The fallen trees were the highest type of damage, with 350 trees, in Muzaffarabad. In case of Balakot, the root shaken was the highest type of damage, claiming 104 trees. In Muzaffarabad, the percentages of damages were 26.5 (Fallen), 1.4 (Top Broken), 2.8 (Dried) and 7.14 (Root Shaken). In case of Balakot, the percentages of damages were 6.6 (Fallen), 0.64 (Top Broken), 4.3 (Dried) and 9.5 (Root Shaken) respectively.

Damages to Under Storey Vegetation:

The damage to under storey vegetation i.e. shrubs and grasses, were corresponded to sampled area that was washed away by the landslides. The Muzaffarabad had 17.35 % of its sampled area affected by landslides. The Balakot area had 6.57 % of its area landslides. Thus, this also shows the damages that occurred to under storey vegetation in the two areas. In addition, it was also found that both the areas were invaded with grasses and shrubs having poor forage values i.e. *Sacharum spontaneum*, *Aristida cylindrical*, *Dodonia viscosa*, *Adhatoda vesica*, *Viburnum nervosum* etc. The percentage cover of grasses in both the areas was high with 62 % (Muzaffarabad) and 65 % (Balakot) respectively. The shrubs, however, occupied 13 % (Muzaffarabad) and 16 % (Balakot) of the sampled area.

Discussion:

The intensity of damage in Muzaffarabad was higher in comparison to Balakot. The damages were high in the plots which encountered landslides. This is in line with Nakaashizuka *et al.* (1993) who have described that avalanche in Japan in 1984 destroyed vegetation area up to 700 ha. The Muzaffarabad had 14 landslides

whereas in Balakot 11 landslides were recorded. IUCN (2006) had also reported that the damages to forest resources were mainly due to landslides and rock falls. The propensity of landslides was due to scarce vegetation in Muzaffarabad. As the study also has shown that the damage to forest trees were encountered more in sparse vegetation plots as compared to dense vegetation plots. Forests, therefore, act as a barrier towards the natural disasters (IUCN, 2006). The other major reason for triggering landslides was slope. The Muzaffarabad had a more sloppy terrain in comparison to Balakot, which was the other cause of these induced landslides and resulting damages. This again is in agreement with Zhenming *et al.* (2001) who investigated in Benton country that earthquake induced landslides were effected due to slopes up to a great deal.

In case of damages to type of crop, the damage was more in pure crop instead of mixed crop. This finding favors the diversity in forest vegetation over monocultures or pure crops. The study has also shown that effect of epicenter of the earthquake on forest trees was insignificant as damaged trees were encountered at various lengths from the epicenter. This is in contradictory to Robert *et al* (1988) who reported 24 % tree mortality and 22.5 % tree injury at 10 km of south east whereas 0.2 % tree mortality and 3.3 % tree injury at 30 km of the same direction.

The damage to understory vegetation was also more in Muzaffarabad than Balakot. This was again subjected to more landslides encountered in the former than the latter. Apart from this, the reduced forage value and increased invasion of undesired plants was noticed in these areas. This cannot be only attributed to the earthquake instead the unchecked grazing and fuel wood collection are the two other reasons for this disorder. Allen *et al* (2000) had quantified the impact of earthquake on forest structure and dynamics of Nothofagus forest of New Zealand. They deduced that forests were not only affected by the earthquake but also the other factors also contributed towards this.

This becomes very important that adequate grazing systems should be employed in the area. Similarly, alternate energy resources should be provided to the local inhabitants to reduce pressure on fuel wood collection. It is also important that the degraded areas should be reforested/afforested in terms of reducing and minimizing earthquake affects. Similarly, mixed plantations should be preferred over pure plantations for creating diverse and effective barriers against the natural disasters.

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