Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.7, No.9, 2017

Environmental Impacts of 2005 Earthquake: A Pre-& Post Disaster Situation Analysis of District Muzaffarabad

Sumeera Siddique Alia Naz, Muhammad Ziad Abdullah Khan Muhammad Rizwan
Department of Environmental Sciences, University of Haripur

Abstract
The research study was carried out in Muzaffarabad District from 20 October to 19 November where a magnitude of 7.6 earthquakes hit the Himalayan region of northern Pakistan and Kashmir in 2005.The epicenter of seismic tremor was found in the region of 19 km north upper east of the city of Muzaffarabad, the capital of Azad Jammu Kashmir. The M7.6 earthquake in district Muzaffarabad caused extensive impacts on the local built, economics, social and natural environment. The present paper found the impact of 2005 earthquake on environmental parameters like water quality, landslide, and forest. Water sampling, questionnaires and interviews were done to analyze the environmental parameters (water quality, Landslides and Forest) in the study area. We compared the pre and post-earthquake of water quality, 2005 earthquake badly affected the chemical properties of water quality (pH, TDS) and biological parameters (E.coli) were changed. By sampling, a significant change was observed in pH, TDS and E.coli after earthquake. The number of landslides were 337(1998- 2005) before, and after earthquake it was increased to 457 (2005-2011), and decreased to 210 (2015). Pre and Post earthquake study also revealed an overall decrease of 17% in conifers forest during 2000-2005 whereas 25% decrease from 2005-2011 were observed. It was concluded that about 6% development increases in the forest sector after the 2005 earthquake. However, it is recommended that the best environmental protection policies should be made with the integration of all the departments and avoids gaps, overlaps and inefficiencies. Roles and responsibilities of the stakeholder need to be defined and coordinated.
Keywords: Earthquake, Environmental protection, Environmental impacts, Water pollution, Biological contamination

1.1 Introduction

Muzaffarabad has an extensive region with an aggregate zone of 6117 sq.km. The whole population of the locale as stated by the 1998 Census was 453957, according to the growth rate the current population is 725,000 in 2015. Region was the most exceedingly terrible influenced environment of Kashmir in the seismic tremor as far as human losses and demolition of physical infrastructure (Halvorson et al, 2010) [1]. On October 8, 2005, at 8:50 a.m. local time, a magnitude $M_w = 7.6$ earth-quake hit the Himalayan region of northern Pakistan and Kashmir (Hussain et al, 2009) [2]. The epicenter of seismic tremor was found in the region of 19 km north upper east of the city of Muzaffarabad which is the capital of Azad Jammu Kashmir (Durrani et al,2005)[3].Due to the 2005 earthquake, the District Muzaffarabad was adversely affected and 35,803 people died in Muzaffarabad and injured were 23,138 persons. As indicated by government figures, 19,000 children died in the seismic tremor, the vast majority of them in far reaching crumples of school structures. The earthquake influenced more than 500,000 families (Qasim et al, 2008) [4].

The environment of the Muzaffarabad area was vulnerable before the earthquake and comprises of fragile mountain ecosystems, significant long term impacts might be likely (Sidle et al 2017)[5]. Although the detrimental losses were sustained to humans and structures, the earthquake had also resulted in adverse impacts on the environment. The impact on ecosystems was often less dramatic than structural damage, due to the relatively slower manifestation of ecosystem damage (Serva et al, 2016) [6].

A detailed environmental assessment of the impacts of the earthquake was needed to quantify losses to forestry, aquatic and terrestrial ecosystems, including biodiversity, and to restore damaged ecosystems (Wang et al, 2012) [7]. Environment was intricately linked to the livelihoods of the affected communities because of their dependence on natural resources. Environment and natural resource issues must therefore be an integral part of all sectorial plans for reconstruction and recovery. While the country AJK had little control over the negative environmental impacts from the earthquake, it can influence preventive environmental and natural resource impacts of reconstruction (Ali et al, 2009) [8]. The analysis of pre post landsliding date shows that the area of Muzaffarabad was already in critical situation. The main issues and challenges which people faced at that time in different sectors is lack of fund ,lack of awareness, Lack of coordination among different agencies/organizations, Lack of adequate capacity for massive afforestation, Lack of technical resources, Lack of monitoring program, Lack of expertise, Lack of water treatment plants, Not proper sewerage system for the disposal of the waste, No community participation, Shortage of staff residences and No proper water filtering treatment plant.

The most visible effect of the earthquake had on the environment, was the land- shearing, liquefaction, and

slides that occurred as a consequence of the earthquake (Rai et al, 2006) [9]. The earthquake destroyed water channels; resulted in the siltation of some rivers and streams; deteriorated forest resources; caused massive destruction to farm lands, especially terraced land situated on steep terrain; and destroyed many fish farms. The disposal of massive amounts of debris from fallen structures was a significant environmental challenge (Naeem et al, 2005) [10].

These parameters were shown through satellite images and described below (Figure.1, 2 &3):

Figure 1: Satellite image Pre 2005 earthquake

Figure 2: Satellite image Post 2005 earthquake

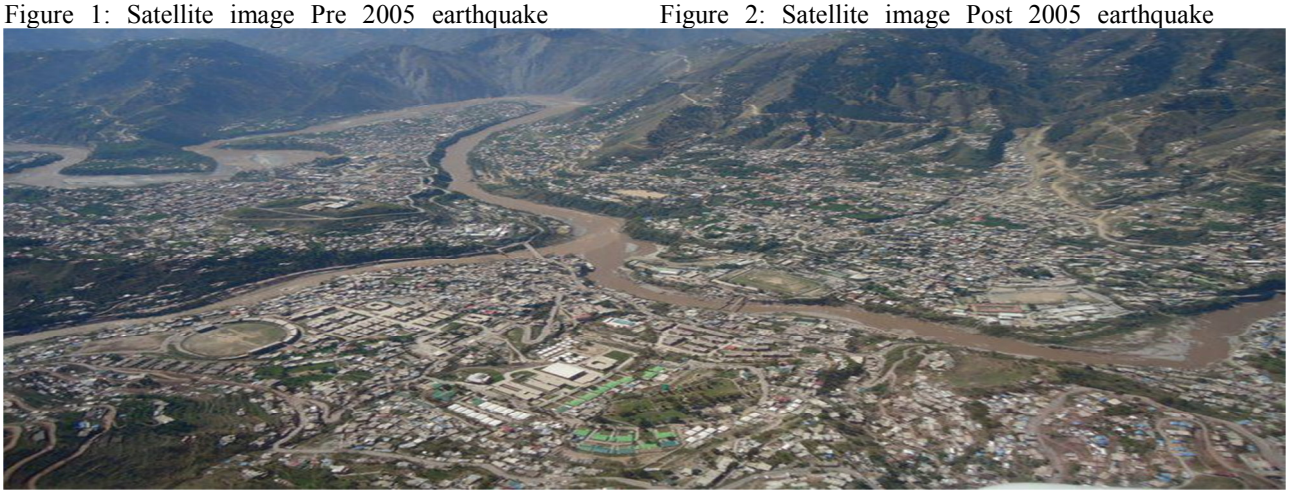

Figure 3: Image Post Earthquake in 2015

The aims of the present study were to compare the water quality of District Muzaffarabad before and after 2005 Earthquake, to assess the impact of damage caused by the landslides before and after 2005 Earthquake (SWOT), to see the impact on Forest cover before and after 2005 Earthquake (SWOT)

2.1. Materials and Methods

Study area

District Muzaffarabad is situated at latitude of 34, 3667 (3422'0.120”N) and longitude is 73, 4667(7328'0.120"E) and altitude is 737 m.The city is placed in a tallness of 2,250 feet over ocean level may be a visitor delight. It may be arranged to a delightful rich green valley that is bounded by forest covered mountains.

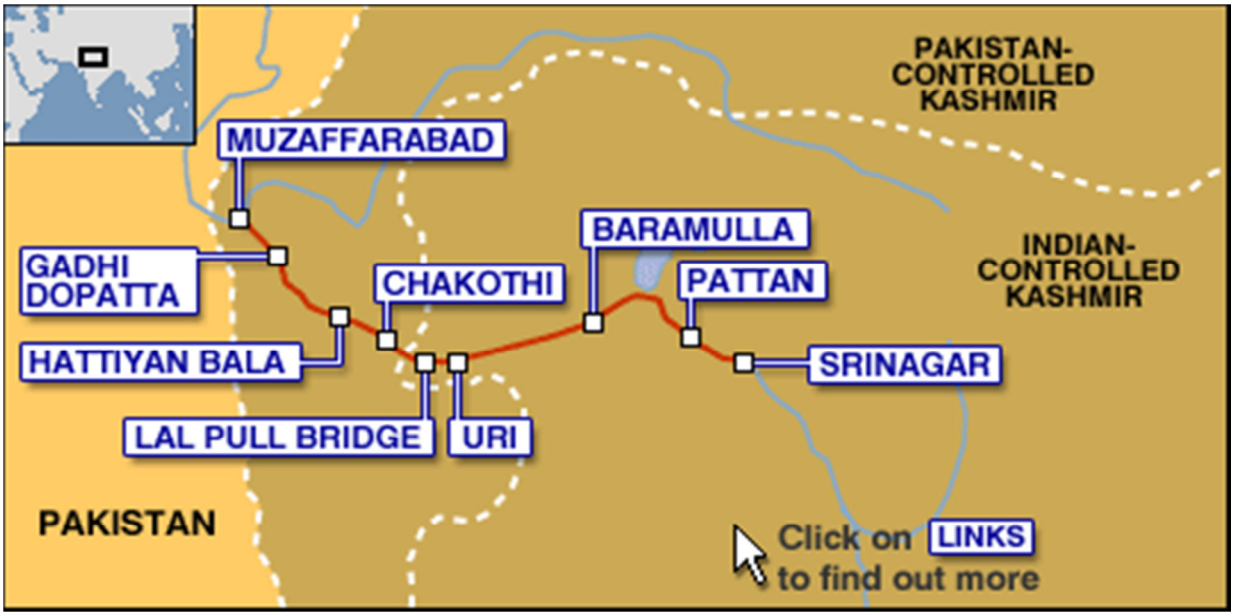

Figure: 4: Map of the study area District Muzafarabad

The data was collected by two ways:

2.1.1. Primary data collections

The primary data was collected by questionnaire from the local community and the officers of the ERRA and Forest Department and interviewed them to get basic information about the impact of pre and post 2005 earthquake on Landslides and Forest.

For analyzing and comparing the water quality, water sampling was carried out. About 9 water samples were collected from different places to study and examined the impact of the earthquake after passing ten year of earthquake. According to World Health Organization, range of pH was 6.1-8.5(WHO, 2013) [11]. During sample collection, proper procedure and precautions were followed and were collected carefully in the cleaned test bottles and then tested in EPA lab of Muzaffarabad (EPA, 2016) [12].

- **Water pH**

The pH of the water sample was measured with a pH meter model PHS-3C. The highest pH value was observed in spring outlet at Dumail near service station, Neelum River at intake WTP and Pumping station & Distribution reservoir at Chatter.

- **TDS**

The TDS of 9 samples of the drinking water were measured by gravimetric method. In this method, each 9 samples of water were separately filtered to check out that there were any suspended material or not having size 2 micron and then placed in a separate beaker .After that ,water in each beaker were separately weighed out and placed on a burner to boil the water .

The water was boiled away leaving the dissolved solids behind as a solid residue. This residue of each sample was separately weighed out to check the TDS in the water of the different places.

Analysis of Biological parameters

- **E.coli**

To find out the microbial contamination in drinking water quality, membrane filtration method was used .This membrane was made of cellulose acetate and had a uniform pore diameter, 4.5um._So bacteria if present were retained on the surface of that cellulose membrane, that was placed on a suitable selective medium in a sterile container and incubated at an appropriate temperature. E.coli were found in this were easily counted.

- **Procedure**

The 9 sample which were collected from 9 different places were separately tested for examining the E.coli in drinking water, for this a 100 ml of water was filtered by using the cellulose membrane under vacuum. Then examined the membrane though which water was passed, under microscope and counted the numbers of the E.coli .After examining and observing that no of E.coli was present in all 9 samples which showed that water was not for drinking.

2.1.2. Secondary data collection

Keeping in examination the objectives of the study, recounted reports were with awareness and seriously reviewed and needful data attained. The secondary data was basically collected from reports of ERRA, SUPARCO and SERA and different books of AJK at glance (2006, 20011, 2013and 2014).

2.1.3. Data interpretation

Collected data from sampling, interviews, questionnaire, visual survey and secondary sources were subjected to statistical method and procedures: e.g. percentage and t test were applied by using SPSS.

3.1 Environmental parameters

3.1.2 Pre Earthquake Water quality of District Muzaffarabad

Water was most essential for life. The local administration in Muzaffarabad had been granted the status of Municipal Corporation. The Public Health Engineering Department (PHED) was in charge of supplying the smelling water the town zone though in rural regions Local Government and Rural Development were in charge of the same. Around 70 percent of the town's people stay in the old extents where the road were slim and immerse. According to the 1998 Registration, channeled water supply scope in urban and rural zones of Muzaffarabad was 99 and 55 percent exclusively. In general, 9 water tests were gathered in Muzaffarabad, out of which five water tests speak to spring water sources utilized by most of the local community for drinking purposes. Just the springs that were situated in regions or in the focal point of the town were all around secured. Out of the 5 tested springs, 3were observed to be defiled with fecal material in the scope of (7 - 44 E.coli/100 ml). The other 6 were not polluted (see Table 1). As shown in the table 1, the water analysis results revealed that the physical quality of sampled water for selected parameters were under recommended range of World Health Organization (WHO) and were suitable for drinking purposes.

Basically two parameters were taken mostly which were physiochemical parameters (pH, TDS) and biological parameters (E.coli).

Table 1. Pre Earthquake Physical and Bacteriological Water Quality Analyzed in Muzaffarabad

S.No	**Sampling point**	**Location**	**Ph**	**TDS mg /l**	**E.coli*/100ml***
1	**Spring outlet**	Sthra under bridge	7.0	334	0
2	**Spring outlet**	Near Agriculture Research Centre	7.0	301	4
3	**Spring outlet**	Near AJK Taxation Council	7.0	368	43
4	**Spring outlet**	Army Camp	7.3	327	0
5	**Spring outlet**	Dumail near service station	7.4	398	0
6	**Neelum River**	Intake of WTP	7.5	97.1	21
7	**Outlet of WTP**	WTP	7.3	94.3	0
8	**Distribution Resvoir**	M-Ghulshan Colony	7.0	95.3	0
9	**Pumping station &Distribution reservoir**	Chatter	6.3	95	0

(Water Quality Monitoring (AJK), 2004)[13]

As shown in the above table, the water analysis results revealed that the physical quality of sampled water for selected parameters were under recommended range of World Health Organization (WHO) and were suitable for drinking purposes.

3.1.2 Effect of 2005 Earthquake on the Water Quality

The earthquake seriously affected the drinking water supply framework in the District Muzaffarabad. Consumption structures, treatment plants, stockpiling repositories, supply mains and dissemination systems were harmed or annihilated. But after the 2005 earthquake the water quality was changed due to the debris, landslides, soil erosion and all waste generated by the death bodies and damaged houses were directly thrown in the river water .This changed the physical and chemical parameters of the water as shown in table 2.

Table 2 . Post 2005 Earthquakes Physical and Bacteriological Water Quality of Muzaffarabad

S.No	**Sampling point**	**Location**	**Ph**	**TDS mg /l**	**E.coli */100ml***
1	**Spring outlet**	Sthra under bridge	6.2	668	12
2	**Spring outlet**	Near Agriculture Research Centre	6.5	405	7
3	**Spring outlet**	Near AJK Taxation Council	6.2	369	43
4	**Spring outlet**	Army Camp	8.7	204	9
5	**Spring outlet**	Dumail near service station	6.4	798	10
6	**Neelum River**	Intake of WTP	6.4	697	21
7	**Outlet of WTP**	WTP	6.5	429	13
8	**Distribution Resvoir**	M-Ghulshan Colony	8.9	657	14
9	**Pumping station &Distribution reservoir**	Chatter	6.3	95	19
	WHO	----	6.5- 8.5	1000 g/l	Nil
	Pakistan	----	6.5-8.5	1000 mg/l	Nil

(Water Quality Monitoring (AJK), 2004)[13]

Wells and springs reported critical diminishment in yield, while water sources in numerous territories went away or were covered under the avalanches.

- **pH**

After the analysis of the study it was concluded that the pH of water was totally changed after the 2005 earthquake in the Pumping station &Distribution reservoir at Chatter, Neelum River at Intake of WTP ,Spring outlet at Dumail near service station ,Distribution Reservoir at M-Ghulshan Colony as these samples were showed acidic nature because all the debris and waste generated after the earthquake were freely thrown in the river water which badly affected the quality of the distributed water and were below from the recommended range by World Health Organization standard .

- **TDS**

After the 2005 earthquake, in the above table the amount of TDS in water samples of the study area was ranged from 95 to 798 mg/l.The analysis of the data concluded that the higher amount of TDS in spring outlet at Dumail near service station and spring outlet at Sthra under bridge was in high quantity due to the high number of Landsliding occurred in the area were blocked the river water as fall directly in water but was not acceptable according to WHO standard range but observed that due to this change it gave bitter taste in drinking water.

- **E.coli**

In the above table, the amount of E.coli was range from7 to 43 /100ml.After the analysis of the post-earthquake data observed that no of E.coli were increased as all the sewerage system, household latrines, public latrines, slaughter houses were damaged and all waste directly thrown in river as there was no side or place where it dispose of so directly thrown in river water .There were some springs which supply water to the area were contaminated with animal waste seeing that a farm animals was also situated near this particular spring.

3.1.3 Water quality in 2015

The earthquake extremely affected the current drinking water supply in the seismic tremor influenced region of Muzaffarabad. After passing ten year of an earthquake, the same 9 areas were selected and examined for the under test for water analysis and compared the area as shown in below table 3 .Pre post data of water quality was obtained from the EPA that was expressed in the table 1& 2.

Table 3. Physiochemical and Bacteriological Water Qualities Analysis in 2015 Muzaffarabad

S.No	**Sampling point**	**Location**	**pH**	**TDS mg/l**	**E.coli */100ml***
1	**Spring outlet**	Sthra under bridge	7.2	340	7
2	**Spring outlet**	Near Agriculture Research Centre	7.1	321	6
3	**Spring outlet**	Near AJK Taxation Council	7.3	380	50
4	**Spring outlet**	Army Camp	7.1	340	5
5	**Spring outlet**	Dumail near service station	5.7	410	113
6	**Neelum River**	Intake of WTP	7.6	120	30
7	**Outlet of WTP**	WTP	7.4	111	88
8	**Distribution Resvoir**	M-Ghulshan Colony	7.8	105	9
9	**Pumping station &Distribution reservoir**	Chatter	6.2	103	6
	WHO	----	6.5- 8.5	1000 g/l	Nil
	Pakistan	----	6.5-8.5	1000 mg/l	Nil

The water samples were collected from various location of district Muzaffarabad. The pH value of samples in spring outlet at Dumail near service station and Pumping station &Distribution reservoir at Chatter were below from the recommended range by World Health Organization standard and these samples were showed acidic nature. The data was statically analyzed through T test among pre post-earthquake and current situation of

water quality and found the Sd1, Sd2 and Sd3 error =.35355±.11785, and after 2005 earthquake 1.07329±. 35776and pH of water quality in 2015 in Muzaffarabad .99121±.33040

Similarly the study was conducted on Effects of the 921 earthquake on the water quality in the river of Taiwan by Liu, 2006 concluded that the pH of water was 6.8 before earthquake due to the proper water treatment plant but after earthquake pH become high which was 6.4(Liu et al, 2007)[14]. The reason of this highest pH was that there was no treatment plant and all debris and sewerage water from the city was fall directly in the river after Earthquake which increase the pH of the water and made it unfit for drinking water.

By applying T test, compared the pre, post and current sampling of water and to analyze the changed in the pH of water. In T test it showed 2tailed significant .000 and acidic in nature, the reason of this acidic nature was observed that all the sewerage, industrial and mining waste which had pH range of 2.0 and more acidic in nature were directly thrown in the river (Figure.5).

Figure 5; Debris affects the quality of water

The fundamental explanation behind the adjustment in ph was expected Municipal water supplied to Muzaffarabad originated from the River Jhelum. The waterway water was lifted from six admission lines and treated in a progression of quick sand channels and clarifiers. Harmed to this water framework ran from harmed to clarifier confounds, engine control units, and dispersion funneling in zones. After passing ten years of earthquake, proper filtering unit was not established due to lack of fund.

TDS

The total solids had an important effect on taste of drinking water. In the above table the amount of TDS in water samples of the study area was ranged from 103 to 410 mg/l.The higher amount of TDS in spring outlet at Dumail near service station was in high quantity which was acceptable according to WHO standard range but observed that due to this slight change it gave bitter taste in drinking water.

Similarly the study was conducted on Post-earthquake impact on Quality of Spring Water in Northern Pakistan by Mirza, 2015 concluded that the amount of TDS was increased from 115_499mg/l to 500mg/l in spring water after the earthquake's .The difference in the amount of TDS was that the affected areas were placed at the foothills of Himalayan forming the catchments area of Indus River. So the contamination with sewage of deforested locations and Landsliding due to earthquake shows substantial variation in elements content (Mirza et al, 2015) [15].

The data was statically analyzed through T test among Pre,post and Current situation after an earthquake and found the Sd1, Sd2 and Sd3 error =134.539 ± 44.846, and after 2005 earthquake 191.360± 63.787andTDS of water quality in 2015 in Muzaffarabad 204.242±68.081.

When applied T test, it was significant in Pre Post earthquake and in 2015 .002.The reason of this significant was the landslides and the erosion of the soils which increase the slit in the river water (Figure,6). Due to this change, it gives bitter taste in water.

Figure 6: Landslides affect the Water quality of the river water

➢ **E.coli**

The no of E.coli in 9 water samples were observed in a high amount mostly in spring outlet at Dumail near service station and Outlet of WTP at WTP which showed that water was not fit for drinking due to this microbial contamination. The no of E.coli in 9 water samples were observed in a high amount mostly in spring outlet at Dumail near service station and Outlet of WTP at WTP which showed that water was not fit for drinking due to this microbial contamination.

Similarly the study was conducted on Water quality assessment of Siran river, after 2005 Earthquake Pakistan by Zeb, 2011 concluded that the real contaminant found in the Siran River was fecal tainting ranging from 95 to 255 after the earthquake, the difference in the number of E.coli was the discharge of residential waste water into the waterway with no treatment (Zeb et al, 2011) [16].

The data was statically analyzed through T test among before ,after 2005 earthquake and in 2015 found the Sd1, Sd2 and Sd3 error = 14.968 ±4.989, and after 2005 earthquake 25.4661± 8.489 and E.coli of water quality in 2015 in Muzaffarabad 31.036 ±10.345 .

After applying the T test it showed that there was a significant change in the water quality after passing ten years of 2005 earthquake still had impact on the water quality. The reason of this increase in no of E.coli was that in the capital city almost all the natural springs were in the lower side of the city and gutter water was believed to be mixing with their water (Figure, 7)

Figure 7: Drinking water pipe passes through gutter channel

According to data, as people mainly depended on spring water for drinking .That carried E.coli with it were polluted by many others factors and showed that water was not fit for drinking purpose which raised the no of hepatitis patient.

The other reason of this polluted water was that after passing ten year of earthquake, all debris and sewerage waste was directly fell in water .There was no proper sewerage system, the water was polluted and unfit for drinking due to this microbial contamination.

After checking the quality of water by sampling observed that it was a big hazard which people of Muzaffarabad faced at that time after passing ten years still there was no improvement and had no filtering unit of water due to the shortage of funds.

3.1.4 SWOT Analysis of Water quality

Strength • Well-developed water treatment plants • Protection of the banks (including of the river lands and constructions) • Providing the water sources for usage • Proper disposal of waste that does not affect the water under ground or water table	**Weakness** • The change of bed morphology in District Muzaffarabad • Lack of funds • Lack of monitoring program • Lack of awareness • Lack of expertise
Opportunity • Proper and modern water filtering plant • Public awareness • Technical experts • Proper sewerage system for the disposal of the waste • Strict laws to regulate the waste thrown in river directly	**Threats** • Life threatening health problem • Directly fall of debris and sewerage waste in river • Landslides

3.2 Landslides

Landslides was a geographical phenomenon which contains a wide assortment of ground development, for example, rocks falls ,intense dissatisfaction of slopes and shallow debris flow. In spite of the fact that gravity following up on an over steepened slope was the essential purpose behind a landslide, there are other contributing components influencing the original slope stability for example, deforestation.

3.2.1 Pre Earthquake Landslides in Muzaffarabad

As stated in 1998 senses, the Landsliding cases in Muzaffarabad and around Muzaffarabad region were not too high, the land and mountains were pretty much stable and if there had any Landsliding incident occurred, it did not made much more human life losses.

During the period of 1998 to 2005 there were only 337 land sliding incidents recorded, (Figure,8) where the total area under Landsliding was 9638 square kilometers.

Figure 8: Landslides in Muzaffarabad

Frequency of land sliding was 0.167 per square kilometers and average land slide size was 0.0286 square kilometers. So as a total percentage area of Landsliding in Muzaffarabad was 0.48 % and this was shown in below table 4.

Table 4. Landslides in Muzaffarabad district

District Muzaffarabad	No. Of Land Slides	Total Area under Landslides - (sq.km)	Frequency of Landslides (no./sq.km)	Average Landslide Size (sq.km)	Landslide Occurrence Rate Interval between landslides (Every sq. km)	% District Area under Landslides
Pre Earthquake in 1998-2005	337	9.638	0.167	0.0286	6	0.48

(SUPARCO - Pakistan Earthquake October 2005 Draft Damage Assessment and Analyst Region) [17]

Analysis of pre Landsliding date shows that the area of Muzaffarabad was already in critical situation of Landsliding and no safety measures had been taken by government to control and prevent the area from further losses.

During my research tour to Muzaffarabad Landsliding areas the inhabitants reported me that landslides located at Kamsar, Dhoga Khas, Patika, Subri and Shahkot were very dangerous even before the earthquake 2005. According to respondents, the areas mentioned above were very high to risks.

3.2.2 Effect of 2005 Earthquake Landslides situation

Multiple mass movements and landslides triggered after 2005 earthquake as enduring threat to population and infrastructure in particular during heavy monsoon rains and earthquake scenario. It triggered due to earthquake destroyed houses and agriculture land, road infrastructures. Large number of tension cracks occurred together with monsoonal climatic conditions increasing landslide activities in Hattian Bala, Kamsar, Dhoga Khas, Patika, Subri and Shahkot, AJK, 18 villages in Muzaffarabad need to be shifted elsewhere due to persistent landslides. Government of Pakistan surveys had identified 118 active slides in Muzaffarabad road sides alone. Muzaffarabad formation and sites near the fault were prone to more landslides.

Table: 5. Landslides caused by the Earthquake in Muzaffarabad district (Based on Comparison of Pre and Post-Quake Satellite Imagery)

District Muzaffarabad	No. Of Land Slides	Total Area under Landslides - (sq.km)	Frequency of Landslides (no./sq.km)	Average Landslide Size (sq.km)	Landslide Occurrence Rate Interval between landslides (Every sq. km)	% District Area under Landslides
Pre Earthquake in 1998- 2005	337	9.638	0.167	0.0286	6	0.48
Post Earthquake 2005 2011	457	11.932	2.123	1.0327	9	2.48

(Owen et al, 2008) [18]

In Muzaffarabad, 2005 seismic tremor exacerbated most existing slides and irritated slants and at the at some point made various new slides and damaged slopes which increase the no of landslides as appeared in above table 5. By investigating the information of review and respondent answer, watched that these slides kept on posturing difficulties to ceaseless supply of materials in the influenced ranges by consistently blocking streets. A significant portion of the mountain range to the north of Muzaffarabad city was lost due to land sliding. Rivers in the city of Muzaffarabad were flooded with material due to land sliding

During study survey to Muzaffarabad Landsliding areas which were highly dangerous zones like Hattian Bala, Nelli, Chinari, located at the left bank of Jhelum river, while gathering the date for post-earthquake Landsliding, 90% of total 100 respondents reported that there were not any safety measures had been taken by the government before earthquake to resist and control the Landsliding and its related dangers. If the governments took some potential safety steps before or worked on preventing these slides so, they did not cause huge damages after 2005 earthquake.

Similarly the study was conducted on the impacts of Landslides and innovative-Landslides Mitigation Measures on the natural Environment by Robert, 2003 concluded that the effects of landslides on vegetation was mostly negative; in some cases, they were catastrophic. However, landslide-caused disasters to flora and fauna were generally local in nature, which allows for species recovery with time .So for preventing this disastrous affect, some Biotechnical approaches to landslide mitigation were used which had much less impact on the environment than traditional concrete and steel retaining structures. Biotechnical slope protection utilizes mechanical elements (structures) in combination with biological elements (plants) to prevent and correct slope failure and erosion with minimum impact on the environment (Owen et al,2008)[18].

3.2.3 Post Earthquake Landslide situation in 2015 in Muzaffarabad

But after passing ten year of 2005 earthquake, there were changes in the situation observed during the field survey.

Table 6. Landslides caused by the Earthquake in Muzaffarabad district

District Muzaffarabad	No. Of Land Slides	Total Area under Landslides - (sq.km)	Frequency of Landslides (no./sq.km)	Average Landslide Size (sq.km)	Landslide Occurrence Rate Interval between landslides (Every sq. km)	% District Area under Landslides
Pre Earthquake in 1998-2005	337	9.638	0.167	0.0286	6	0.48
Post-Earthquake in 2005 -2011	457	11.932	2.123	1.0327	9	2.48
Post Earthquake 2011-2015	120	7.11	2.102	3.213	7	1. 02

(Owen et al, 2008) [18]

Now government takes some positive steps to overcome the Landsliding situation and its further damages. Due to this no of slides decreased as shown in the table 4.6.The reasons of this decrease in no of slides were that during the reconstruction, the government of Muzaffarabad had used many important measures to protect the roads from damages caused by land sliding. Some of the basic measures that had been taken for protection of roads from land sliding were: slope stabilization measures including retaining walls, gabions (Figure, 9).

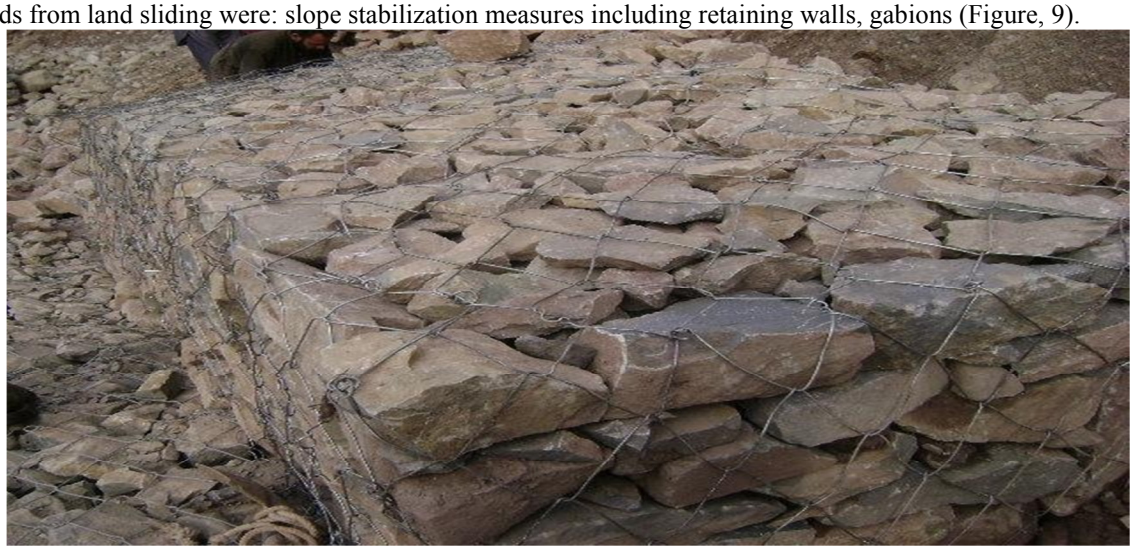

Figure 9: Gabions Walls

This reconstruction phase also included repair of hydraulic structures bridges, culverts, causeways) and drainage improvements. Also, the government had constructed road lay-byes, parapet walls, guardrail, and road marking and road furniture.

- **Technical Prevention Measures from Landsliding**

While on the other hand, few technical prevention measures had also been established. In this measure system, on two main critical sites in Muzaffarabad, early warning system for landslides had been installed. Which is, ten wooden battens, and two digital extensometers along with two rain gauges were installed to monitor the slope movements. The extensometer installed in Ranjata area was then connected to a siren to warn the community (Figurer, 10).The system was set up in a way that when the instrument observed a ground movement more than the specified one, it sent signals to the alarm unit, which would then activate the revolving light and the siren to warn the community of the danger of landslide. Necessary settings were made in order to prevent false alarms due to contact by animals or human error. The instruments were installed in the wooden boxes to protect them from water and direct sunlight, as well as from security point of view. All the wood used in the installation had properly been painted in order to protect it from severe weather conditions.

Figure, 10: Using extensometer apparatus

The other prevention measure done by the government of Muzaffarabad was that the certain sign boards had been prepared to facilitate warning and evacuation systems. These boards carried some important instructions for the public regarding landslides. Moreover 10 small sign boards were prepared and installed in the project area, these boards pointed towards evacuation paths and safe areas in case of a landslide event occurred .After the system was successfully set up by GSP; it was handed over to local administration of the Muzaffarabad city as per agreement with JICA.

The third prevention method which was applied that an over headed bridge was made with the help of FWO in Miyani Bandi to protect community from further damages caused by land sliding .Due to these prevention methods about 90 % protection was given to the community from land sliding caused by earthquake. People of Muzaffarabad was now happy by using these prevention measures as number of losses had been decreased ,over headed bridges were made to prevent further land sliding .People had got well awareness about the measures that should be immediately taken to deal with land sliding problems.

3.2.4 SWOT Analysis of Landslides

Strength	**Weakness**
Early warning system against landslides • Gaps identified and proper implementation of the policy • Technical resources and other prevention method used to stop landslides. • Availability of funds • Trained staff • People aware about the damages of landslides • Awareness about replantation	• No policy in Muzaffarabad about landslides • Lack of funds • Lack of technical resources • Lack of public awareness • Lack of modern equipment • Lack of trained staff
Opportunity	**Threats**
• Implementation of the land use plans • Strong policy implementation • Modern and technical methods are used to prevent further landsliding • Awareness about plantation on the critical slopes sides • Replantation on the road sides	• No further strong policy implemented • Earthquake • Over flow river • Community depend on government • Dislocation

3.3 Forest

4.2.3.1 Pre Earthquake Forest Situation

The total area of forest in Muzaffarabad was 2,18,168 acres which includes the trees species of Chir Pine (*Pinus Roxburghii*), Deodar (*Cedrus Deodara*), Fir (*Abies Pindrow*), Kail (*Pinus Wallichiana*) and Blue Pine. Pre-earthquake study revealed general decline of 3% in conifer timberland from 2000-2005. However an overall annual decrease of 5% was recorded in the total forest prior to the earthquake. This decrease was due to the consumption of conifer forest wood as fuel wood and as for construction purposes and after analyzing the data

observed that there was no alternative provided to the community to reduce burden on fuel wood. Additionally there were not any specific replantation programs to recover the forests population. There was also a lack of awareness among inhabitants about the importance of plantation.

3.3.2 Effect of 2005 Earthquake on Forest

As per the harm valuation of environment, the influenced zones in AJK convey critical natural significance for the whole nation. The greater part of the forested zone of Muzaffarabad was made on the two waterways Jhelum and Neelum and major contributory watersheds for Tarbela and Mangla dams individually. After an analysis of the data concluded that about 82 % decreased in forest sector was observed in District Muzaffarabad due to 2005 earthquake. The reasons of most detectable obliteration to physical environment was created by the area cutting, liquefaction and slides that maintained long after the seismic tremor because of repetitive consequential convulsions. It brought about waterways and streams siltation, devastation to water channels, woodland and homestead land. A graph 7 reflects range of damages by the earthquake to forest land in district Muzaffarabad. The total area of forest in Muzaffarabad was 218,168 acres out of which 52360 acres was damaged due to earthquake and 1, 65,808 acres remained in their original position as shown in the Figure 11.

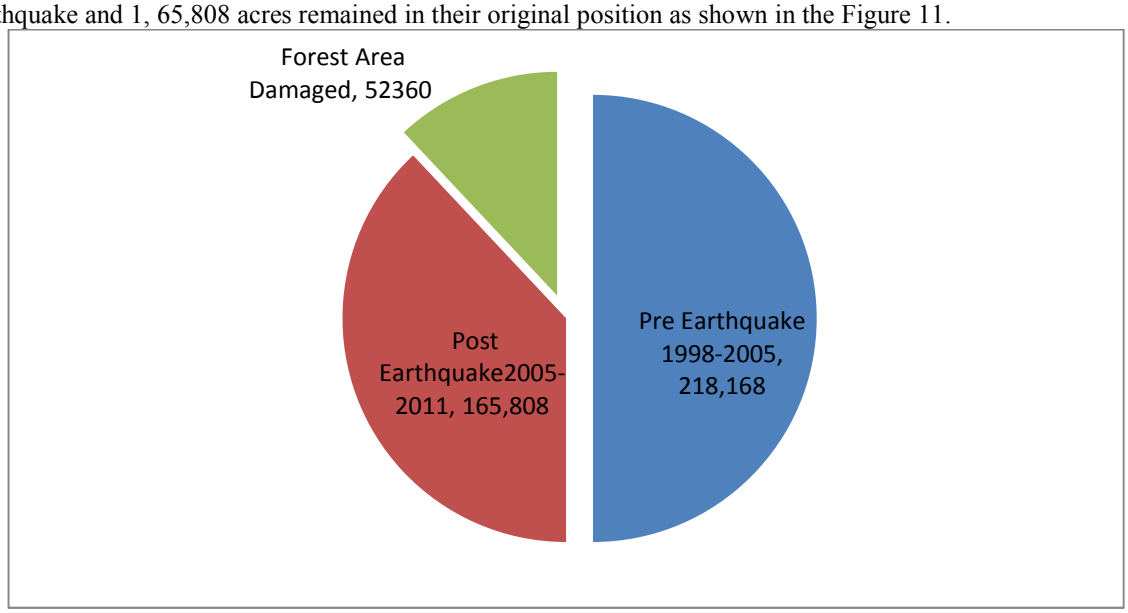

Figure 11: Pre and Post Forest Statics of Muzaffarabad (ERRA, 2007)[19]

A broad field study of an area was accompanied to assemble reliable data. After the analysis of the data it was concluded that the forest wood was continuously decreasing by 3% annually which is not a very big loss as compare to the loss in the forest sector which came after the 2005 earthquake. Post-earthquake study revealed an overall decrease of 17% of forest wood from 2005-2007, while 25% decrease from 2007-2011was observed. Whereas, the total decrease of forest area was 82%. The main reason for this decrease in forests was increased demand of wood for reconstruction purpose. Additionally, increased forest degradation rate due to triggered land sliding (in higher elevation and less forested/barren land) highlights the protective role of forest. During the data collection about pre post earthquake damages of forest most of the difficulties were faced as due to 2005 earthquake forest department offices were badly affected and completely damaged and all pre record about forest were destroyed.

Similarly the study was conducted on Effects of natural disaster on conservation policies: The case of the 2008 Wenchuan Earthquake, China by Vina, 2011 concluded that more than 10% of the forests in Wenchuan Country, Sichuan province China were immediately affected by the 2008 earthquake, offsetting some gains in forest cover observed since the enactment of the conservation programs. But without the enactment of these conservation programs, the combined effects human disturbance and earthquake- induced landslides could have severely reduced the region's forest cover. The continuation –and enhancement-of incentives for participating in conservation programs will be important for reducing the environmental impacts of the combined effects of human disturbance and natural hazards not only in the study area but also in many disaster prone regions around the world (Vina et al, 2011) [20].

3.3.3 Forest situation in 2015

According to the current statistics of AJ&K Forest Department, total area under forests in Muzaffarabad was 1.400 million hectares in which Coniferous forest was 0.14 million hectares, scrub forest was 0.004 million hectares whereas range land was 0.370 million hectares. After the analysis of the data, observed that about 6% increase development in the forest sector from 2011- 2015. Although there was a slight development seen in the

forest sector but was much appreciated that government took some positive steps in the development of the forest sectors. The government of Muzaffarabad distributed 1000 plants among local people annually for growing and increase the reforestation process. Also creating awareness about the importance of forest by participate the local community in the reforestation.

Table 4.7Forest Statics of Muzaffarabad

Forest	1998	2006	2015
Coniferous	3.293	0.105	0.14
Irrigated plantation	0.102	0	0
Reverine Bela Forest	0.001	0	0
Scrub Forest	0.041	0.001	0.004
Coastal Forest	0	0	0
Range Lands	0.024	0.009	0.370
Total	3.461	0.115	0.514

(Hussain SA, 2013) [21]

However, the government of AJ&K had spent Rs.79.178 million on restoration of smashed forest in Muzaffarabad forest division and also created awareness among people about the importance of forest in their daily life.

3.3.4 SWOT Analysis of Forest

Strength • Availability of foundation, including office structures, examination cottages ,backwoods check posts, timberland streets, vehicles, hardware and working apparatuses • Availability of prepared proficient woodland administrators and strong staff • Well characterized parts and obligations and work codes and strategies • Working Plans for orderly timberland administration • Close association with open through ranch and mindfulness battles • Supporting woodland groups in employment exercises	**Weakness** • Lack of proper control on working of forest contractors • Lack of adequate capacity for massive afforestation • Budgetary constraints and lack of adequate financial resources • Lack of adequate planning and control on grazing and rangeland protection • Political interference and pressures • Delays in preparation of new Working Plans • Lack of authentic resource database • Lack of skills and training opportunities in new emerging fields related to forestry
Opportunity • Availability of blank areas for afforestation /reforestation to increase forest area and cover • Continued major role in forest protection, conservation and development • Enhanced emphasis and market value of ecosystem services • Enhanced emphasis on protection and development of watershed	**Threats** • Damages because of backwoods flames, surges, earthquake, land sliding and bug and creepy crawly assaults • Imbalance in free market activity of timber and fuel wood • Conversion of woodland area to different employments • Indiscriminate provincial street development and mining exercises in timberland zones

4. Conclusion

Results show that that the 2005 Earthquake severely affected the all aspects of the environmental parameters (water quality, Landsliding and Forest) of District Muzaffarabad. From the study examine the pre- post-earthquake impacts on the environmental parameters in District Muzaffarabad. After checking the quality of water by sampling observed that it was a big hazard which people of Muzaffarabad faced at that time. There was no sewage system or water treatment plant and all waste which was generated due to collapsed buildings and other sewerage and domestic waste was directly fall in river which affects the quality of water. There were significant change occurred examined by sampling after earthquake in pH, TDS and E.coli which were about .00, .001and .033,made water unfit for drinking at some places .But still in 2015 ,there were no sewerage system all waste directly thrown in water and lack of modern water treatment plant, lack of water quality monitoring system in Muzaffarabad.

The analysis of the study showed that Pre earthquake the Landsliding cases in Muzaffarabad and around Muzaffarabad region was not too high. During the period of 1998 to 2005 there were only 337 land sliding

incidents recorded, where the total area under landsliding was 9638 square kilometers. But after 2005 earthquake, the numbers of landslides were increased to 457 and the total area under landsliding was 11.932 Sq.km and due to earthquake destroyed houses, agriculture land, road, infrastructures and displacement. In 2011-2015, the numbers of landslides were decreased to 120 as government used some technical prevention measures like gabions walls, sign boards and over headed bridge etc .The analysis of pre post landsliding date shows that the area of Muzaffarabad was already in critical situation so it needs more prevention measures to prevent from further future losses.

Pre and Post earthquake study reveal an overall decrease of 17% in conifer forest from 2000-2005 whereas 25% decrease from 2005-2011 was observed. The main reason for this degradation of forests was increased demand of wood for reconstruction purpose and fuel wood. Additionally, increased forest degradation rate was due to triggered landsliding after earthquake. According to the current statistics of AJ&K Forest Department, total area under forests in Muzaffarabad was 1.400 million hectares in which Coniferous forest was 0.14 million hectares, scrub forest was 0.004 million hectares whereas range land was 0.370 million hectares. After the analysis of the data, observed that about 6% increase development in the forest sector after the 2011-1015. However, the government of AJ&K had spent Rs.79.178 million on restoration of smashed forest in Muzaffarabad forest division.

5. Recommendation

To maintain the water quality, all spring sources should be protected and tapped and water supply line should be repaired as soon as possible. Water treatment plant should be installed and water monitoring systems should monitor the water quality on daily basis.

Plantation over the excavated sides of roads should be ensured to control the land erosion. Different technical prevention measures should be used like extensometers, gabion walls or retention walls and sign boards. For awareness, different programs should be created among local community about afforestation, reforestation and its importance.

References

[1] Halvorson SJ & Parker Hamilton J (2010). In the aftermath of the Qa'yamat: 1 the Kashmir earthquake disaster in northern Pakistan,*Disasters*,*34*(1):184-204.

[2] Hussain A, Yeats RS & MonaLisa (2009). Geological and tectonic setting of the 08 October 2005 Kashmir Earthquake, Journal of Seismology, (13):315-325.

[3] Durrani AJ, Elnashai AS, Hashash Y, Kim SJ, & Masud A (2005). The Kashmir earthquake of October 8, 2005: A quick look report, *MAE Center CD Release 05-04,* (1):5-7.

[4] Qasim MJ , MonaLisa & Asif MK (2008).Post-October 08, 2005, Muzaffarabad earthquake scenario,Journal of Himalayan Earth Sciences,(41) :1-6

[5] Sidle RC, Gomi T, Rajapbaev M, & Chyngozhoev N (2017). Can earthquake fissures predispose hillslopes to landslides?-Evidence from Central and East Asia, In *EGU General Assembly Conference Abstracts,*(19):10639.

[6] Serva L, Vittori E, Comerci V, Esposito E, Guerrieri L, Michetti AM & Tatevossian RE (2016).Earthquake hazard and the environmental seismic intensity (ESI) scale, *Pure and Applied Geophysics*, *173*(5):1479-1515.

[7] Wang YK, Fu B & Xu P (2012). Evaluation the impact of earthquake on ecosystem services, Procedia Environmental Sciences, (13), Pages 954-966.

[8] Ali Z, Qaisar M, Mahmood T, Shah MA, Iqbal T, Serva L & Burton PW (2009). The Muzaffarabad, Pakistan, earthquake of 8 October 2005: surface faulting, environmental effects and macroseismic intensity,*Geological Society, London, Special Publications*, *316*(1):155-172.

[9] Rai DC, & Murty CVR (2006). Effects of the 2005 Muzaffarabad (Kashmir) earthquake on built environment, *Current Science- Bangalore*, *90*(8):1066.

[10] Naeem A, Ali Q, Javed M, Hussain Z, Naseer A, Ali SM & Ashraf M (2005). A summary report on Muzaffarabad earthquake, Pakistan, *University of Engineering and Technology, Peshawar, Pakistan*, 2 (1):1-7.

[11] World Health Organization (2013) .Guidelines for drinking-water quality, (4):86 -123.

[12] Environmental Protection Agency (2016).What are Water Quality Standards?Washington, D.C.: U.S, (2):03-17.

[13] Water Quality Monitoring in Azad Jammu & Kashmir (AJK) [Cited in 2004 December], Available from: *https://cmsdata.iucn.org/downloads/pk_ajk_wqm_rep2004.pdf*

[14] Liu CP & Sheu BH (2007). Effects of the 921 earthquake on the water quality in the upper stream at the Guandaushi experimental forest, *Water, Air, & Soil Pollution*, 179(1):19-27.

[15]Mirza MA, Khuhawar MY, Arain R, Choudhary MA, & Mahar, KP (2015). Post-Earthquake Impact on Quality of Spring Water in Northern Pakistan, *Asian Journal of Chemistry*, *27*(5): 1658

[16] Zeb BS, Malik AH, Waseem A & Mahmood Q (2011). Water quality assessment of Siran river, Pakistan. *International Journal of Physical Sciences*, *6*(34):7789-7798.

[17] SUPARCO-Pakistan Earthquake October 2005 Draft Damage Assessment and Analyst Region, Available from Webpage:
pagewww.ndma.gov.pk/Publications/District%20Profile%20Muzaffarabad.pdf
[18] Owen LA, Kamp U, Khattak GA, Harp EL, Keefer DK, & Bauer MA (2008). Landslides triggered by the 8 October 2005 Kashmir earthquake, *Geomorphology*, *94*(1):1-9.
[19] ERRA (2007).District Profile –Muzaffarabad, Earthquake Reconstruction and Rehabilitation Authority and Affiliates, 3(1):28-29.Available from Webpage*: http://www.erra.gov.pk*
[20]Vina A, Chen X, McConnell WJ, Liu W, Ouyang Z & Liu, J (2011). Effects of natural disasters on conservation policies: the case of the 2008 Wenchuan Earthquake, China, *Ambio*, *40*(3): 274-284.
[21] Hussain SA (2013). Azad Jammu Kashmir & At a Glance, Available from Webpage:
https://pndajk.gov.pk/AJKGLANCE/1985-2015/AJK%20at%20a%20Glance%202013.pdf