Earthquake consequences & micro-seismicity of Kashmir valley. An estimation of future risks& safety

Ayaz Mohmood[1], Kaiser Bukhari[2], Maqbool Yousuf[3]

[1,2,3]*National Institute of Technology Srinagar*

ABSTRACT

Kashmir valley, situated in the western extent of NW Himalaya holds an infrastructure of 7 million people. The region has always been in concern about the consequences of earthquakes and by the conclusions that has been brought downby various earthquake scientists. However, the earthquake data suggests that the valley has witnessed only upto the maximum of 5.5 magnitude earthquake from the year 1900 onwards inside its periphery. Apart from 7.6, 2005 Muzaffarabad earthquake whose epicenter was away from Kashmir basin, it has witnessed only three greater magnitudes of 5-5.5 inside its boundary from last 100 years. The effort was made to delineatethe faults in the region by the use of hyper spectral remote sensing followed by the field validation. The total of 17 faults have been delineated inside the Kashmir basin. The mechanics of faults and their topographic orientations suggest that few of those faults have a capability of holding a greater magnitude earthquake. An attempt was made to analyze the region through its micro seismicity level by studying the densities and magnitudes of previously occurred earthquakes as well as the densities and length of faults in the Kashmir basin. The study suggests that the western side of the valley indicates the maximum severity of damage than the central and eastern side. The work has also found that the most of the civic infrastructure indicates weak behavior to resist against the earthquake forces. Being as the Himalayan valley and surrounded by the greater thrust systems by all sides, the study implies towards the urgent need of cooperation between all the sectors in the region to avoid the greater damage from the earthquakes shocks.

Keywords: Kashmir valley, Earthquakes, Faults, Micro-seismicity, Remote sensing.

I INTRODUCTION

The Himalaya is a classic example of an orogenic system created by continent–continent collision of Indian and Eurasian plates[12],[13]. Its youthfulness and remarkable exposure make the orogeny an ideal for studying diverse geologic processes related to mountain building. Its potentialas a guide to decipher the feedback processes betweenlithospheric deformation andatmospheric circulationhas motivated concentrated research in recentyears on the history of the Himalayan–Tibetan orogeny, its role in global climate change, and its interaction with erosion ([19],[20], [25],[29].[28],[32],[2]).In spite of the broad interests, it has become increasingly intimidating for both a beginner and an experienced Himalayan geologist to comprehend the intricate complexity of the Himalayan geology in its entirety.The lack of an updated overview of the entire Himalayan orogeny makes it difficult to assess how the Himalayan deformation has responded to the well-understood plate boundary conditions and its impact on the overall Indo-Asian collision zone and evolution of great rivers in Asia ([27],[14],[22],[5],[18],[9]).The evidence of paleo-lake formation due to movements along active faults, landscape marked by ravines and the development of canyons, narrow gorges, entrenched channels and waterfalls are all indicative of active tectonics and fault displacement and its influence over the evolution of the landscape ([31],[33],[34],[26],[24]).Several studies have proved that the careful evaluation of geomorphic features and geomorphic indexes such as the Valley width, heightratio, the Mountain-front sinuosity index, the River gradient index etc. provide a wealth of information which assists our understanding of the influence of tectonics on landscape change and drainage evolution ([6],[31],[16],[7],[8]). It has also been suggested that an understanding of past drainage evolution may be derived from present-day river patterns, which provide an insight into pastdeformational events within active mountain belts ([15]). Numerous conceptual models and field investigations suggest that in tectonically active regions fault growth and associated deformation have a direct control in shaping the landscape and drainage evolution ([17],[11],[21],[35]).Studies suggest that the entire Himalayan arc is ripe enough to hold earthquakes >8M ([4]). Seismic gaps along two-thirds of the Himalaya that have developed in the past five centuries, when combined with geodetic convergence rates of approximately 1.8m/century, suggests that one or more M=8 earthquakes may be overdue in the Himalaya arc in near future([3]). A recent seismic hazard analysis of Northwest Himalayan region has categorized the regionunder high hazard zone as this region hosted the deadliest 2005 Kashmir earthquake ([23]). The Himalayan zone is divided into three seismic gaps – Kashmir gap, Central gap and Assam gap. The Jammu and Kashmir, Himachal Pradesh and Uttrakhand falls under Kashmir gap which is the highest earthquake prone seismic zone. Considering the published literature and consequences in the Kashmir basin, the study was formulated to access the structural setup and seismic analysis to find out the intensity of vulnerability in the region. Apart from geological fieldwork, the remote sensing have also found healthy in delineating the faults and evaluating the structural setup in any region ([10]).

II STUDY AREA

The Kashmir valley is situated in NW-Himalaya, an oval-shaped basin trending in the NNW–SSE direction (Fig.1). It is bounded by lofty and glacier-chiseled mountain chains of the Himalaya. It is an intermountain valley filled with unconsolidated gravel, sand and mud succession appearing as plateaus above the present plain of Jhelum and its tributaries.Geologists believe that about ten crore years have passed when Kashmir Valley which was once a lake called Satisar, the lake of goddess Sati, came into its present form. For hundreds of million years Kashmir Valley is supposed to have remained under Tethys Sea and the high sedimentary-rock hills seen in the valley now were once under water. Geologists have come to believe that Kashmir Valley was earlier affected by earthquakes. Once there was such a devastating earthquake that it broke open the mountain wall at Baramulla and the water of the Satisar lake flowed out leaving behind latchstring mud on the margins of the mountains known as karewas. The karewas being in fact the remnants of this lake confirm this view. The karewas are found mostly to the west of the river Jhelum where these table-lands attain a height of about 380 meters above the level of the Valley. These karewas protrude towards the east and look like tongue-shaped spurs with deep ravines. Jhelum river, joined by the various tributaries from all around the mountains becomes the only drainage network which drains the water out from the valley.

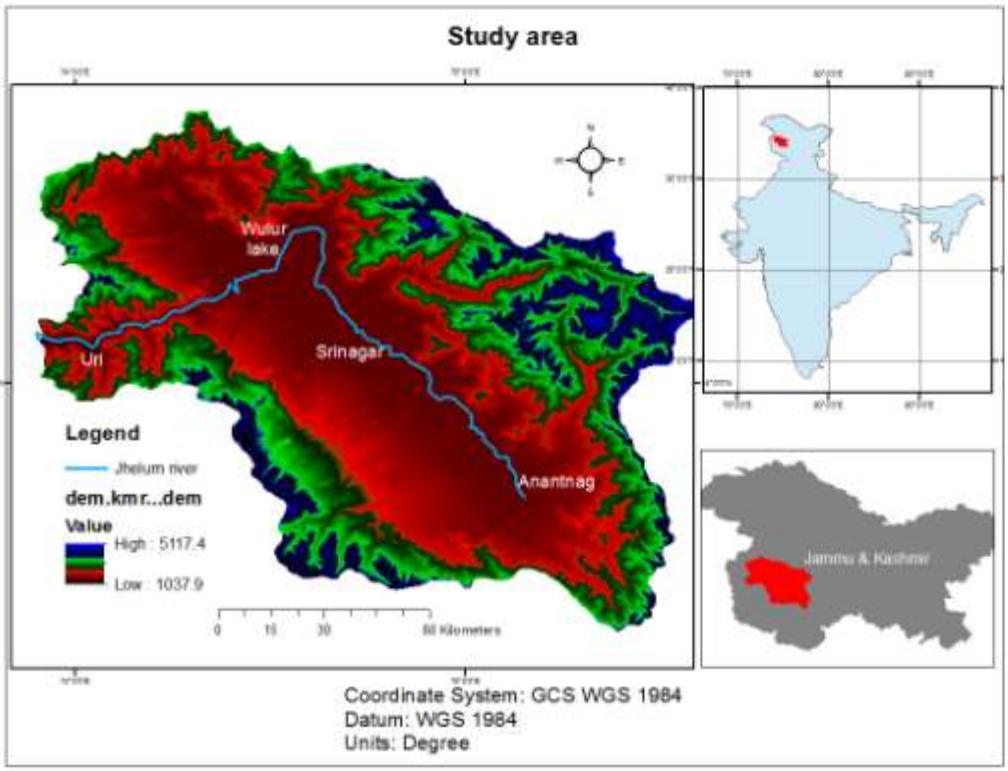

Figure.1: Study area

III RESULTS & DISCUSSION

The earthquake data from 1900 onwards was collected from various sources (USGS, NOAA, NEIC, IRIS, IMD) and were filtered and plotted by means of software's (Fig.2). The study shows that the valley has witnessed only three magnitudes of 5.5 in 1967, 5.2 in 1975 and 5.2 in 2005 from the last 120 years inside its periphery. However the valley has witnessed an earthquake shake of 7.6 magnitude outside its boundary in 2005 at Muzaffarabad causing a damage inside the region. Apart from this, the valley has witnessed a numerous earthquakes below the magnitude of

4 which indicates the continuous release of energy till date. In contemporary, the region has not shown much of the release of energy along its eastern sides, being nearer to the greater Himalayan thrust systems.The fault map generated by the remote sensing techniques([10],[1]) shows the valley has deformed following the main deformation mechanisms of the Himalayan systems. The total of 17 faults have been delineated inside the valley and their orientations behavior has also been studied by the fieldworks (Fig.3). The valley is entirely surrounded by the Himalayan thrusts as main central thrust (MCT), main boundary thrust (MBT), main boundary fault (MBF) in the west, main mantle thrust (MMT) in the north and the greater Himalayan thrusts in the east as shown in the map. The study has found Balpur fault as previously delineated by ([30]) can play a major role in hosting an earthquake in the future time as the length and activeness of the fault have a serious concerns. Apart from this fault, the study brought the concerns of two more faults, one on the eastern side of greater Himalaya and other on the north western side that can be readily available to host any future earthquakes. As per the study, the faults have already hosted the smaller magnitudes in the area and have developed the more activeness towards the hosting sites.

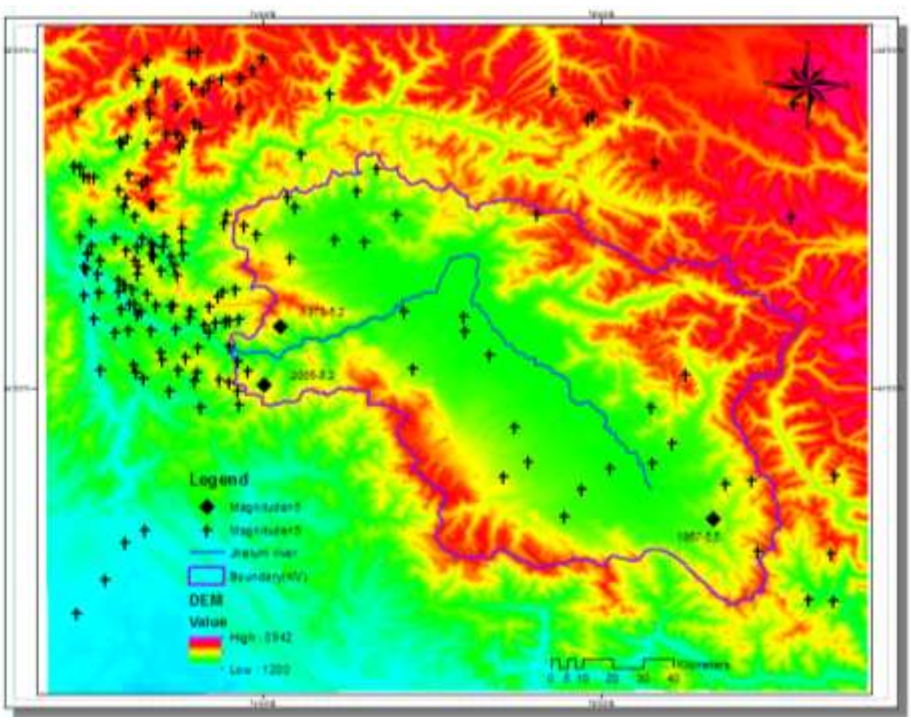

Figure.2: Location of earthquakes in and around the Kashmir valley.

IJARSE
ISSN: 2319-8354

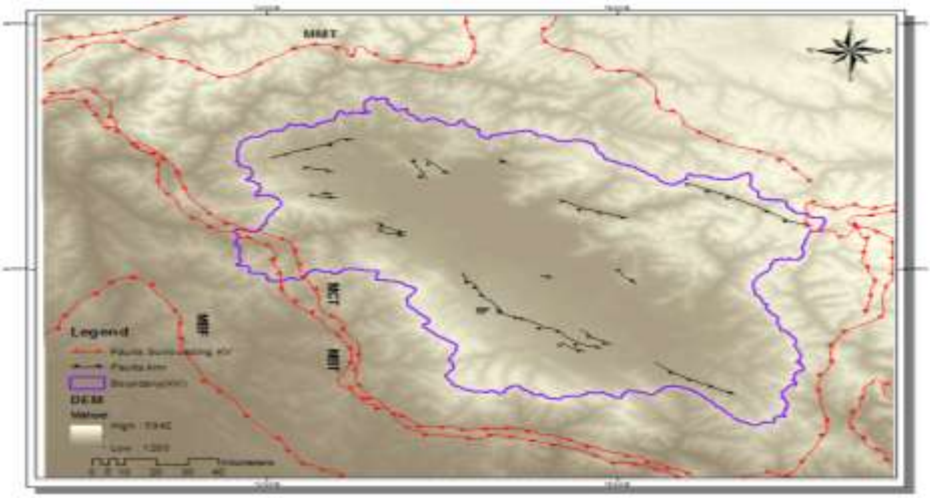

Figure.3: The Tectonic/Fault map of Kashmir valley.

The study was able to bring out the micro seismicity map by considering the site of previously occurred earthquakes, the structural/fault setup and the topographic visions(Fig.4). The region has been viewed as the seismic zone IV-V by the seismologists. The present study dived the region on the basis of severity of the damage that can happen inside the valley. The map prepared, shows that 30% of the valley is very severe to earthquake damage and lie mostly on the western Kashmir followed by 50% severe and 20% moderate. The Infrastructure of the valley gives the worrying scenes about earthquake resistance and one of the reason is that people have built up their structures without considering the earthquakes codes of the region.

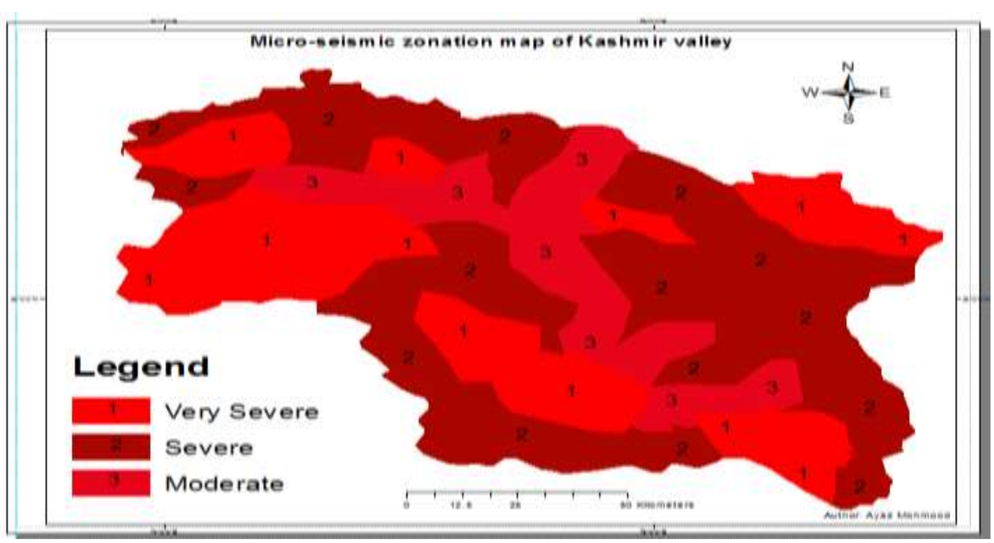

Figure.4: Micro-seismic zonation map of Kashmir valley.

IV CONCLUSIONS

The valley, being the formation of Himalayan collision, remains always in the hazard consequences. According to the literature, it has witnessed the heavy damage in the past and was always claimed to be slave of seismic activities. The threat was not only form the earthquake events but also the natural hazards like landslides and floods which always remained directly or indirectly associated with these earthquakes. However the earthquake data from the last century suggests that either there is a seismic gap which can cause a huge earthquake in future or the energies may have released in enormous smallermagnitudes to resist the greater one. The valley seems structurally very deformed and if the large energies are still accumulated as claimed by various seismologists then the region may not lack in hosting the greater magnitude earthquakes. In case of greater magnitudes, the valley doesn't seem ready to face earthquake consequences because of poorly civic infrastructure setup. The region seems to be effectively examined by integrated geoscientific approaches to bring out the proper micro-seismic zonation maps and the cooperation from all the sectors to attempt the lifesaving methods.

REFERENCES

[1]Ayaz Mohmood et.al (2017), An Introduction to the methodology of remote sensing and GIS for the consideration of civic infrastructure in Indian subcontinent. A case studies from Kashmir basin, Sixth Indian Young Geotechnical Engineers Conference 6IYGEC2017, 10-11 March 2017, NIT Trichy, India.

[2]Beaumont, C., Jamieson, R.A., Nguyen, M.H., Lee, B., 2001. Himalayan tectonics explained by extrusion of a low-viscosity crustal channel coupled to focused surface denudation. Nature 414, 738– 742.

[3]Bilham, R. (2004), Earthquakes in India and the Himalaya: tectonics, geodesy and history, Annals of Geophysics, VOL. 47, N. 2/3, April/June.

[4]Bilham, R., and N. Ambraseys, (2004) Apparent Himalayan slip deficit from the summation of seismic moments for Himalayan earthquakes, 1500-2000, Current Science.

[5]Brookfield, M.E., 1998. The evolution of the great river systems of southern Asia during the Cenozoic India–Asia collision: rivers draining southwards. Geomorphology 22, 285– 312.

[6]Bull, W.B., McFadden, L.D., 1977. Tectonic geomorphology north and south of the Garlock fault, California. In: Doehring, D.O. (Ed.). Geomorphology of Arid Regions. Proceedings of the Eighth Annual Geomorphology Symposium. State University of New York at Binghamton, Binghamton, N. pp. 115–138.

[7]Burbank, D.W., Anderson, R.S., 2001. Tectonic Geomorphology. Blackwell Science, p. 274.

[8]Champel, B., van der, B.P., Mugnier, J.L., Leturmy, P., 2002. Growth and lateral propagation of fault-related folds in the Siwaliks of western Nepal: Rates, mechanisms, and geomorphic signature. Journal of Geophysical Research 107 (2111), 2-1–2-18.

[9]Clark, M.K., Schoenbohm, L.M., Royden, L.H., Whipple, K.X., Burchfiel, B.C., Zhang, X., Tang, W., Wang, E., Chen, L., 2004. Surface uplift, tectonics, and erosion of eastern Tibet from largescale drainage patterns. Tectonics 23, TC1006.

[10]Dar AM (2015) An Approach of Remote Sensing and GIS for the Delineation of Lineaments in the Suru Valley (Ladakh-Himalayas). J Remote Sensing & GIS 4: 144. doi:10.4172/jrsg.1000144

[11]Delcaillau, B., Deffontaines, B., Floissac, L., Angelier, J., Deramond, J., Souquet, P., Chu, H.T., Lee, J.F., 1998. Morphotectonic evidence from lateral propagation of active frontal fold; Pakuashan anticline, foothills of Taiwan. Geomorphology 24, 263–290.

[12]Dewey, J.F., Bird, J.M., 1970. Mountain belts and new global tectonics. Journal of Geophysical Research 75, 2625– 2685.

[13]Dewey, J.F., Burke, K., 1973. Tibetan, Variscan and Precambrian basement reactivation: products of continental collision. Journal of Geology 81, 683–692.

[14]Dewey, J.F., Cande, S., Pitman, W.C., 1989. Tectonic evolution of the India–Eurasia collision zone. EclogaeGeologicaeHelvetiae 82, 717– 734.

[15]Friend, P.F., Jones, N.E., Vincent, S.J., 1999. Drainage evolution in active mountain belts: extrapolation backwards from present-day Himalayan river patterns. Special Publication International Association of Sedimentologist 28, 305–313.

[16]Gregory, D.I., Schumm, S.A., 1987. The effect of active tectonics on alluvial river morphology. In: Richard, K. (Ed.), River Channels: Environments and Processes. Basil Blackwell, Oxford, pp. 41–68.

[17]Gupta, S., 1997. Himalayan drainage patterns and the origin of fluvial megafans in the Ganges foreland basin. Geology 25, 11–14.

[18]Hallet, B., Molnar, P., 2001. Distorted drainage basins as markers of crustal strain east of the Himalaya. Journal of Geophysical Research 106, 13697–13709.

[19]Harrison, T.M., Copeland, P., Kidd, W.S.F., Yin, A., 1992. Raising Tibet. Science 255, 1663– 1670.

[20]Harrison, T.M., Yin, A., Ryerson, F.J., 1998a. Orographic evolution of the Himalaya and Tibetan plateau. In: Crowley, T. (Ed.), Boundary Conditions for Climate Changes. Oxford University Press, New York, pp. 38–72.

[21]Hitchcock, C.S., Kelson, K.I., 1999. Growth of late Quaternary folds in southwest Santa Clara Valley, San Francisco Bay area, California: Implication of triggered slip for seismic hazard and earthquake recurrence. Geology 27, 391–394.

[22]Le Pichon, X., Fournier,, Jolivet, L., 1992. Kinematics, topography, shortening, and extrusion in the India–Eurasia collision. Tectonics 11, 1085– 1098.

[23]Mahajan et.al (2010), Probabilistic Seismic Hazard Map of NW Himalayan and in adjoining area India, Natural Hazard, Volume 53, 443–457.

[24]Malik, J.N., Nakata, T., 2003. Active faults and related Late Quaternary deformation along the northwestern Himalayan Frontal Zone, India. Annals of Geophysics 46 (5), 917–936.

[25]Molnar, P., England, P., Martinod, J., 1993. Mantle dynamics, the uplift of the Tibetan Plateau, and the Indian monsoon. Review of Geophysics 31, 357– 396.

[26]Nakata, T., 1972. Geomorphic history and crustal movements of foothills of the Himalaya. Sendai, Institute of Geography, Tohuku University 77p.

[27]Patriat, P., Achache, J., 1984. India–Eurasia collision chronology has implications for crustal shortening and driving mechanism of plates. Nature 311, 615– 621.

[28]Ramstein, G., Fluteau, F., Besse, J., Joussaume, S., 1997. Effect of orogeny, plate motion and land sea distribution on Eurasian climate change over the past 30 million years. Nature 386, 788–795. Rao, M.B.R., 19

[29]Royden, L.H., Burchfiel, B.C., King, R.W., Wang, E., Chen, Z., Shen, F., Liu, Y., 1997. Surface deformation and lower crustal flow in eastern Tibet. Science 276, 788–790.

[30]S. Ahmad et al. (2015) Geomorphic evidence of unrecognized Balapur fault segment in the southwest Kashmir basin of northwest Himalayas, Geomorphology,Volume 250, 1 December 2015, Pages 159-172

[31]Seeber, L., Gornitz, V., 1983. River profiles along the Himalayan arc as indicators of active tectonics. Tectonophysics 92, 335–367.

[32]Tapponnier, P., Xu, Z.Q., Roger, F., Meyer, B., Arnaud, N., Wittlinger, G., Yang, J.S., 2001. Geology-oblique stepwise rise and growth of the Tibet plateau. Science 294, 1671– 1677.

[33]Valdiya, K.S., 1996. Quaternary palaeolakes in Kumaun Lesser Himalaya: finds of neotectonic and palaeoclimatic significance. Current Science 70, 157–161.

[34]Valdiya, K.S., 1999. Reactivation of faults, active folds and geomorphic rejuvenation in Eastern Kumaun Himalaya: wider implications. Indian Journal of Geology 71 (1), 53–63.

[35]Van der Woerd, J., Xu, D., Li, H., Tapponnier, P., Meyer, B., Ryerson, F.J., Meriaux, A.S., Xu, Z., 2001. Rapid active thrusting along the northwestern range front of the Tanghe Nan Shan (western Ganshu China). Journal of Geophysical Research 106, 30475–30504.