

History of Natural Disasters in Kashmir Valley, Jammu and Kashmir with Special Reference to Earthquakes

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ABSTRACT: Hazards are part of our lives. It is impossible to live in a totally risk free environment. Natural hazards are indeed geophysical events, such as earthquakes, land sliding, volcanic activity and flooding. Earthquake is a natural disaster that lasts a few milliseconds to a few minutes and can cause immense destruction resulting in loss of life, property and infrastructure. They have caused the most devastating natural disasters in the 20th and 21st centuries. The Kashmir region is seismically active earthquake prone area. It has witnessed frequent earthquakes in the past and earthquakes big and small will continue to occur. It is not possible to predict when and where an earthquake will strike, nor its intensity. The study aims to analyze the trend of occurrence of earthquakes in Kashmir valley, Jammu and Kashmir.

KEYWORDS: Hazards, Earthquakes, Seismically active, Kashmir region.

I. INTRODUCTION

A natural hazard only becomes a disaster when it affects a human population that is exposed and vulnerable. The occurrence and extent of disasters thus depends on three basic variables: hazard; exposure; and vulnerability [1]. A natural disaster is the occurrence of an extreme hazardous event that impacts on communities causing damage, disruption and casualties, and leaving the affected communities unable to function normally without outside assistance [2] [3]. Natural disasters like earthquake, landslide, flood, cyclone, forest fire, volcanic eruption and major accidents are quite common in different parts of the world. These lead to the loss of life, property damage and socio-economic destruction [4]. According to a 2004 report by the United Nations Development Programme (UNDP), about 75 percent of the world's population was affected at least once by natural disasters during the 20 year period from 1980 to 2000 [5]. Nature presents humankind with a set of opportunities and risks which vary greatly in their spatial distribution [6]. The aim of the present study is to analyze the earthquake history of Kashmir valley, Jammu and Kashmir.

Earthquakes are one of the most important types of hazards having the greatest impacts in becoming disasters [7]. They are one of the nature's greatest hazards on our planet which have taken heavy toll on human life and property since ancient times [8]. Earthquake is a natural disaster that lasts a few milliseconds to a few minutes and can cause immense destruction resulting in loss of life, property and infrastructure [9]. They are the most feared natural hazards, as they occur without any recognizable warning, are unpredictable in space and time and inflict heavy losses in less than a minute duration [10]. They are caused by the abrupt release of strain that has built up in the earth's crust [11]. Earthquakes are rapid-onset, short-duration, time-specific and potentially high-consequence events. They have local to regional geographical impact [12], often causing significant secondary hazards and cascading impacts such as fire, flooding and release of hazardous chemicals [13]. Earthquakes have caused the most devastating natural disasters in the 20th and 21st centuries [14] [15]. For many victims the experience of an earthquake is one that causes inexpressible, sudden and deep shock, often with long-term ongoing psychological consequences and the impact is often widespread [16] [17] [18] [19] [20] [21]. About 1 lakh earthquakes of magnitude more than 3 hit the earth every year. According to

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conservative estimate, more than 15 million human lives have been lost and damage worth 100 billion dollars has been inflicted due to this [22]. The global earthquake death rate (1990-2014) has shown an increasing trend (Fig. 1).

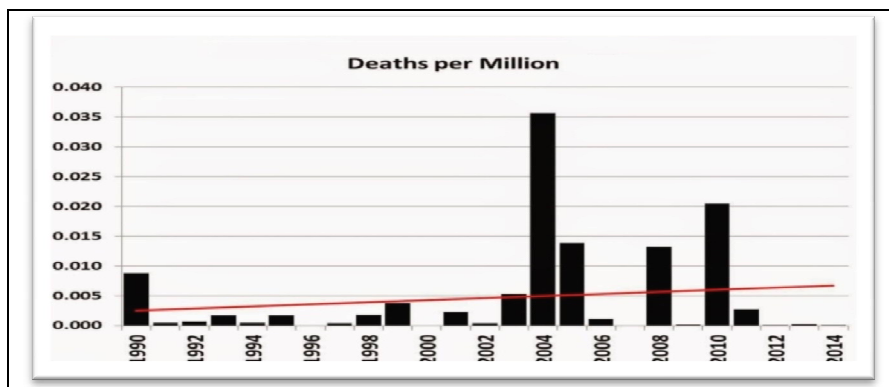


Fig. 1: Global Earthquake Death Rate: 1990-2014 [23]

Earthquake loss depends not only on the hazard caused by earthquakes, but also on exposure (social wealth) and its vulnerability [24]. The primary consequence of concern in earthquakes is of course human casualties, i.e. deaths and injuries [25]. An overview of past history based on seismicity pattern of Kashmir region was carried out by Ghaffar and Abbas (2010). Sharma, Kumar and Ghangas (2013) studied more than 60 earthquake events that took place in the state of Jammu and Kashmir from which it was illustrated that most of the earthquakes were taken place in between and around the main boundary thrust and Main Central Thrust. Their study indicated that the entire region is tectonically active and continuous build up stress along those thrusts and faults has been released from time to time. Earthquake geology of Kashmir basin and its implications for future large earthquakes was presented by Shah (2013). A historical record of 13 earthquakes in the valley over the last millennium indicates that the Kashmir valley is a locus of active deformation. According to the study, the active geomorphic evidences presented suggested that these historical events must have ruptured the surface, which are now preserved as active fault scraps.

II. STUDY AREA

The Kashmir valley located in North-western Himalayas lies between the Pir-Panjal and the Zaskar thrusts, making it vulnerable to earthquakes [29]. Kashmir region is seismically active earthquake prone area. The Vale of Kashmir is located in the western part of the Himalayan mountain range on the site of a prehistoric lake created by the uplift of the mountains between Indian and Pakistan Administered Kashmir. Over geological time, this lake gradually silted in and the alluvium from the mountains became the fertile soil of the valley floor. This is responsible both for the area's rich agriculture and for its earthquake vulnerability [30]. The Kashmir valley especially the Jhelum valley floor has the vast tracts of land comprising of alluvial soil. In the Kashmir valley, the soils vary from clayey loams to loams [31] [32]. The thick sediments in the Jhelum River valley and around lakes are likely to amplify shaking significantly [33]. The state being the zone of weakness and largely occupied by the young folded mountains is subjected by the severe crumpling of the rock beds, resulting into earthquakes of various intensity and magnitude [34]. The Kashmir region is seismically active earthquake prone area [26]. It has witnessed frequent earthquakes in the past and earthquakes big and small will continue to occur. It is not possible to predict when and where an earthquake will strike, nor its intensity [35]. Since the fifteenth century eleven severe earthquakes were recorded in Kashmir, all of long duration and accompanied by great loss of life. In the nineteenth century there occurred four severe earthquakes [36].

III. HISTORY OF EARTHQUAKES IN KASHMIR VALLEY

The Himalayan Mountains are the tallest and the youngest on Earth. Earthquakes in the Himalaya are related to the formation and uplift of these mountains. As the Indian tectonic plate is moving and converging with the Asian tectonic

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plate at a rate of five to six centimeters a year, the Himalaya is uplifting along active faults. This process of continent to continent collision, Himalayan uplift, faults and earthquakes has been going on for the past 55 million years, predating the appearance of humans on Earth. Earthquakes are also parts of the same geological processes [37]. As the Indian plate continues to push into Eurasian plate, stresses accumulate at the faults marking the boundaries between these two gigantic plates [38] [26]. This collision between the Indian and the Eurasian plates took place during the Late Cretaceous to Early Eocene times [39]. The Himalayan zone is divided into three seismic gaps; Kashmir gap, Central gap and Assam gap. The Jammu and Kashmir, Himachal Pradesh and Uttarakhand falls under Kashmir gap which is the highest earthquake prone seismic zone [27]. Bilham's studies show that the Indian tectonic plate is moving along a major fault beneath the Himalaya at about 1.8 centimetres a year. (This is about one-third of the total plate movement of India toward Asia - 5.4 centimetres a year. The remaining rate of plate motion is responsible for tectonic deformation and uplift in Tibet and other parts of central Asia) [37]. As per the 2002 Bureau of Indian Standards (BIS) map (Fig. 2), this state also falls in Zones IV & V [40].

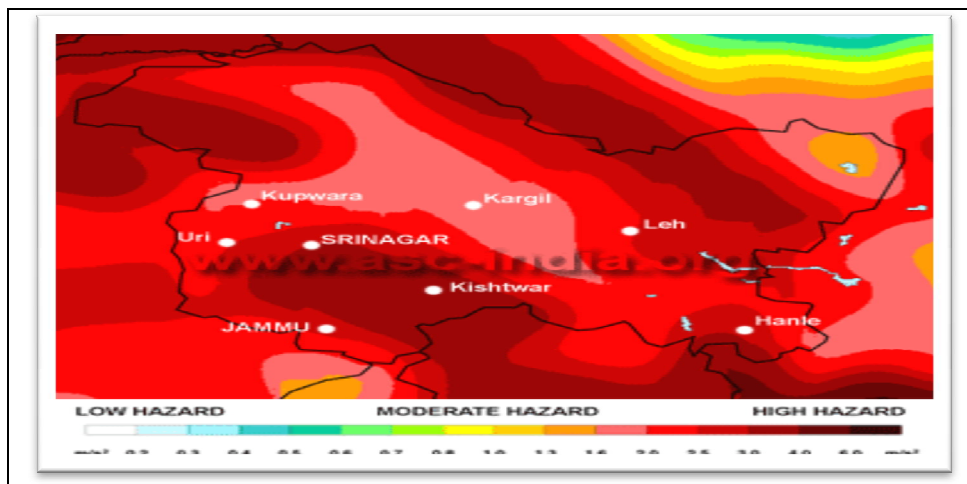


Fig. 2: High seismic hazard zones of Jammu and Kashmir [40]

Kashmir region is very important related to seismic activity in the Great Himalaya. The history of earthquakes goes back to 1505 in this region [26]. Earthquakes in the Himalaya, in general, and in Kashmir, in particular, pose serious challenges. Historical records of the past centuries show that several big earthquakes have destroyed parts of the Himalayan settlements (and many earthquakes have possibly gone unrecorded). The earthquake record of the past decades shows that the Kashmir region has been hit at least by one earthquake of magnitude 5 or larger every year or two [37]. The tectonic movement in the region is responsible for the creation of the Himalayan mountain ranges through compressive and bending stresses. The subduction mechanism has triggered a few great and several intermediate earthquakes in a band of about 50-80 km width and an arc length of about 2500 km [41] [42] [43] [26]. The 2,000 km long Himalayan orogenic system was formed due to continent-continent collision between the Indian and Eurasian plates, which started in the Eocene [44] [45] [46] and continues till today. The Kashmir Valley is included on the western side of this long orogenic belt. The ongoing collision deformation along the Himalayan orogenic belt is distributed differently along the central and western portions of the belt. For example, the bulk shortening along the central part is mainly accommodated along the Himalayan Frontal Thrust (HFT) system [47] [48] [49] [50] [51]. In contrast, along the NW Himalayas, the convergent deformation is not concentrated on the front and is distributed across the width of the belt [52] [53]. Distributed deformation is also supported by the active geomorphic observations within the Kashmir Basin [54] [55] [56]. A historical record of 13 earthquakes in the valley over the last millennium, which includes the damaging earthquakes of 1555 and 1885, indicates that the Kashmir Valley is a locus of active deformation [56] [28]. Fig. 3 illustrates some of the major active faults around the Kashmir basin.

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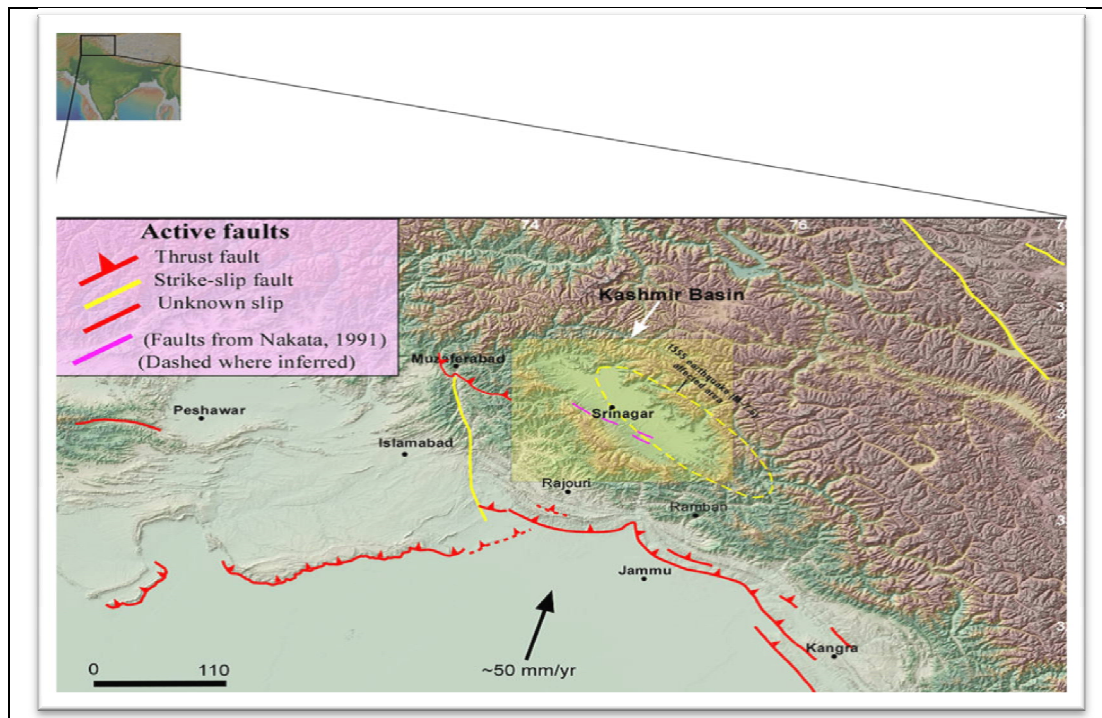


Fig. 3: Some of the major active faults around the Kashmir basin [28] [54] [50] [57] [58] [59] [60] [61] [62]

The arrow shows the average motion of Indian plate relative to Eurasia [63]

A catastrophic earthquake in Kashmir occurred in 1555 but there is no data to assign it a magnitude or location. In 1885, the Kashmir earthquake occurred near Srinagar. The total affected area was 1,00,000 sq.miles which includes Baramulla and Pattan [64]. Approximately 3,000 people were killed and some villages were completely destroyed. Kashmir region has been the host of many great earthquakes from centuries [26]. A review of the historical as well as recent earthquake activity in northern India indicates that different parts of the region are characterized by a moderate to very high level of seismic activity. It is observed that large and damaging earthquakes have occurred in the region. The Jammu and Kashmir has been a region of major seismic activity. Some of the largest earthquakes in India have occurred in this zone [27]. Table II shows the data of significant earthquakes from 1904 - 2015, almost 111 years of the Kashmir region. During these years 102 earthquakes occurred in this region. But the quakes with magnitude 4.5 and more are included in table [26] [65]. Fig. 4 depicts the trend of occurrence of earthquakes at intervals of 7 years as per Table II. Table I gives a list of severe earthquakes that are known to have occurred in Kashmir along with the details of damages occurred.

Table I: List of severe earthquakes that are known to have occurred in Kashmir

| Year | Extent of damages caused |
|------------------|--|
| 2082-2041 B.C | Due to the earthquake, the earth in the middle of the city of Sandimatnagar was rifted and water gushed out in a flood and submerged the whole city. This submerged city forms the bed of the Wular lake* ¹ . |
| 1500 A.D | This earthquake destroyed many houses and many people perished. The shocks continued for three months* ¹ . [33] list as 24 September 1501. |
| 1552 | This visitation of the earthquake was very severe. Many fissures occurred. Several springs became dry and new springs flowing with water were produced. The shocks continued for two months* ¹ . |
| 1 September 1555 | Earthquakes continued for several (7) days. Landslides and liquefaction* ² . |
| 1662 | This earthquake was also severe. Many houses were destroyed and many people perished. The shocks continued for a long period* ¹ . |
| 1668 | The buildings rocked like cradles* ² . Constant shocks of earthquake occurred one day from evening |

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| | to next morning but no loss of life was caused* ¹ . [33] list as 23 June 1669. |
| 1735 | A severe shock of earthquake occurred which threw down thousands of houses and its shocks continued for three months* ¹ . Buildings of the city and hamlets razed to the ground* ² . [33] list as 24 March 1736. |
| 1778 | Countless houses were razed to the ground. The shocks continued for one year during which the people were living out of their houses* ¹ . |
| 1784 | Loss of life was immense. The shocks continued for about three months* ¹ . |
| 1803 | Many houses were destroyed amongst which was the spire of the Shah-i-Hamdan mosque* ¹ . Earth ripped apart and people were buried under walls* ² . |
| 26 th June 1828 | The earthquake shook down some 1,200 houses and perhaps 1,000 persons were buried to death underneath them. Just before sunrise, another shock occurred accompanied by a terrific and lengthened explosion and 20 similar shocks followed in the course of the day. The earth opened in several places about the city and foetid water, rather warm, rose rapidly from the clefts and then subsided. These clefts in the soil being soon closed left scarcely any traces. For the next two months, there were never less than 100 and sometimes 200 or more shocks in the day, all accompanied with an explosion* ³ . |
| 1863 | The earthquake occurred in the close hours of the morning. Fissures were produced in different places, but no loss of life occurred. The shocks continued for three months* ¹ . |
| April 1873 | The earthquake took nearly 3,000 lives and a few thousand of cattle heads* ⁴ . |
| 30 th May 1873 | It was quite violent with rumbling sounds. A fissure about 225 m long, about 100 m wide and about 22 m deep occurred at Laridura in Kruhen Pargana to the south of Baramulla town. The effects of this earthquake were quite disastrous. Over 10,000 houses were destroyed, 3,400 human lives and 40,000 cattle heads were lost. The shocks continued for two and a half months. Many irrigation springs disappeared and a big landslide occurred on the sloping ground of Laridura* ⁴ . |
| 1878 | The volcanic action was still at work under the valley of Kashmir was unfortunately again illustrated in this earthquake, when 16 houses together with their inmates were buried down into a chasm caused by an earthquake at Kundabal village near Manasbal* ³ . |
| 30 th May 1885 | It was the most disastrous earthquake which was felt from Gilgit to Simla roughly over an area of about 1,30,000 sq. miles. Its effects were destructive to a considerable degree over an area of about 500 square miles. Its epicenter was a few miles to the west of Srinagar. Subsequently, shocks were felt upto 16 th August. The dreadful visitation in Kashmir in 1885 caused much loss of life and property. Thousands of houses were destroyed and there was an atmosphere of general panic. People slept for many days in the open. It is thought that over 20,000 houses, 30,000 cattle and 3,000 human beings were destroyed. The air stank with rotten carcasses. Along the valley, whole villages were overthrown and their inhabitants crushed, especially at and around Magam. At Sopore the fort, mosque, houses and dak bungalow were overthrown. At Baramulla, the fort, dak bungalow and three-fourths of the houses were wrecked. The massive temples at Patan and Martand were also much shaken. At Srinagar, the barracks fell, killing nearly 60 soldiers* ^{3, *4} . |
| 20 th September 1902 | The epicenter of this earthquake was near Hindukush and it was felt all over the Kashmir Valley. At Srinagar, it lasted for about two and a half minutes. It was also felt severely at Gulmarg and Drosh. The loss to life and property in this earthquake was insignificant* ⁴ . |
| 4 th April 1905 | The earthquake had a magnitude of 8 at the Richter scale. The first shock was recorded at 6.10 am in Srinagar and it lasted for about three and a half minutes. It was also recorded at Leh, Kargil, Skardu, Uri, Dras and Muzaffarabad. The shocks were of mild intensity and much damage was not done to life and property* ⁴ . |
| 1907, 1912, 1917, 1921, 1931, 1952, 1984, 1986, 1992, 1998 and 1999 | Earthquakes of mild intensity were recorded* ⁴ . |
| 8 th October, 2005 | This earthquake with a magnitude of 7.6 took place at 8:50 a.m. The epicentre of the earthquake was 34.493° North and 73.629° East, some 10 kilometres (6.2 miles) northeast of Muzaffarabad (capital of the Pakistan-administered Kashmir), and very close to the boundary of the Indian and Asian tectonic plates. The focal depth at of the earthquake was about 26 kilometre (16.2 miles). Most of the casualties were in the Muzaffarabad area and the Balakot area, although the tremors were felt as far north as Kabul and as far south in Delhi. In the days that followed, more than a |

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| | dozen aftershocks, including a magnitude 6.2 tremor two hours after the main shock, continued to shake Kashmir. Earthquake-triggered landslides destroyed many houses on hillsides and blocked roads. In terms of death toll, this was the most fatal earthquake in the recorded history of the Himalaya* ⁵ . |
| 26 th October, 2015 | This earthquake had a magnitude of 7.5 with its epicenter in the Hindukush mountain region of Afghanistan. This earthquake caused damage to property. Cracks appeared in most multi storeyed public and private buildings but no loss of life occurred* ⁶ . |

Source: *¹[66]; *²[67]; *³[68]; *⁴[34]; *⁵[69]; *⁶[37]; *⁷[36]; *⁸[70]; *⁹[33], *¹⁰[65]

Table II: Data from 1st January 1904 - 26th October 2015 with Magnitude ≤ 7.6

| Years | Number | Magnitude | Years | Number | Magnitude | Years | Number | Magnitude | Years | Number | Magnitude |
|-------|--------|-----------|-------|--------|-----------|-------|--------|-----------|-------|--------|-----------|
| 1904 | 1 | 4.6 | 1932 | - | - | 1960 | - | - | 1988 | - | - |
| 1905 | - | - | 1933 | 1 | 4.6 | 1961 | - | - | 1989 | - | - |
| 1906 | - | - | 1934 | - | - | 1962 | - | - | 1990 | - | - |
| 1907 | 1 | - | 1935 | - | - | 1963 | 2 | 5.1 | 1991 | - | - |
| 1908 | - | - | 1936 | - | - | 1964 | 1 | 4.9 | 1992 | 1 | 5.4 |
| 1909 | - | - | 1937 | 1 | 4.5 | 1965 | 1 | 5.2 | 1993 | - | - |
| 1910 | - | - | 1938 | - | - | 1966 | 1 | 5.1 | 1994 | - | - |
| 1911 | - | - | 1939 | - | - | 1967 | 1 | - | 1995 | - | - |
| 1912 | 1 | - | 1940 | - | - | 1968 | 1 | 4.6 | 1996 | - | - |
| 1913 | - | - | 1941 | - | - | 1969 | 1 | 4.9 | 1997 | - | - |
| 1914 | - | - | 1942 | - | - | 1970 | 6 | 4.8 - 4.9 | 1998 | - | - |
| 1915 | - | - | 1943 | - | - | 1971 | 7 | 4.8 - 5 | 1999 | - | - |
| 1916 | - | - | 1944 | - | - | 1972 | 4 | 4.5 | 2000 | - | - |
| 1917 | - | - | 1945 | - | - | 1973 | 8 | 4.6 - 5.1 | 2001 | - | - |
| 1918 | - | - | 1946 | 1 | 4.5 | 1974 | 3 | 4.5 - 4.8 | 2002 | - | - |
| 1919 | 1 | - | 1947 | - | - | 1975 | 4 | 4.7 | 2003 | 4 | 4.7 |
| 1920 | - | - | 1948 | 1 | - | 1976 | 4 | 4.5 - 5.2 | 2004 | 6 | 5 - 5.7 |
| 1921 | - | - | 1949 | 1 | - | 1977 | 9 | 4.6 - 5.2 | 2005 | 1 | 7.6 |
| 1922 | - | - | 1950 | 1 | - | 1978 | 9 | 4.5 - 5 | 2006 | - | - |
| 1923 | - | - | 1951 | - | - | 1979 | 4 | 4.5 - 4.8 | 2007 | - | - |
| 1924 | - | - | 1952 | - | - | 1980 | 4 | 5.2 - 6.1 | 2008 | 1 | 6.4 |
| 1925 | - | - | 1953 | - | - | 1981 | 2 | 4.5 - 4.6 | 2009 | - | - |
| 1926 | - | - | 1954 | - | - | 1982 | 2 | - | 2010 | - | - |
| 1927 | - | - | 1955 | - | - | 1983 | - | - | 2011 | - | - |
| 1928 | - | - | 1956 | 1 | - | 1984 | - | - | 2012 | - | - |
| 1929 | - | - | 1957 | - | - | 1985 | - | - | 2013 | 1 | 5.8 |
| 1930 | - | - | 1958 | - | - | 1986 | - | - | 2014 | 1 | 4.9 |
| 1931 | - | - | 1959 | 1 | - | 1987 | - | - | 2015 | 1 | 7.5 |

Source: [26] [65]

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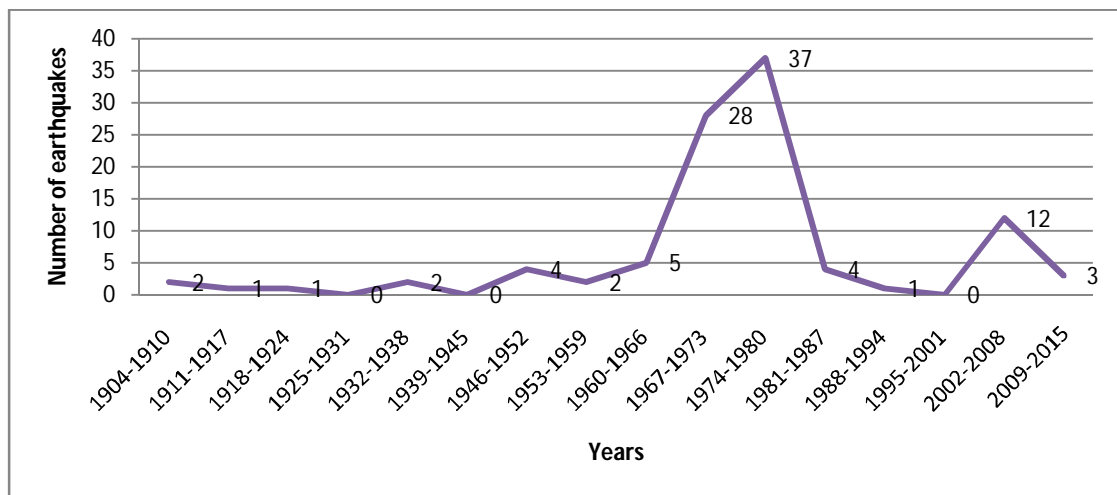


Fig. 4: Trend of occurrence of earthquakes since 1st January 1904 - 26th October 2015 [26] [65]

IV. CONCLUSIONS

The Kashmir region is seismically active earthquake prone area. It has witnessed frequent earthquakes in the past. Since the fifteenth century eleven severe earthquakes were recorded in Kashmir, all of long duration and accompanied by great loss of life. In the nineteenth century there occurred four severe earthquakes. The study reveals that the occurrence of earthquakes in Kashmir valley is showing an increasing trend which is a matter of concern. Some disastrous earthquakes like that of 1555, 1885 and 2005 have hit the valley. Although the advent of earthquakes can't be controlled but their impact on the environment, as well as the population can be minimized by undertaking proper mitigation strategies.

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