SPATIO TEMPORAL OCCURRENCE OF EARTHQUAKES IN THE HIMACHAL HIMALAYA

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Abstract

Himachal Himalaya is one of the states in India which lies towards the northwest part of the Himalayas and is environmentally, ecologically and geologically vulnerable to earthquakes. It has been subjected to many earthquakes of which Kangra earthquake is worth to be mentioned. The entire state is considered to be highly susceptible to earthquake, with its 32 per cent area prone to very high damage risk zone and remaining 68 per cent area prone to high damage risk zone according to the Vulnerability Atlas of India. In spite of the intensities of earthquakes being high, 95 per cent of the house types are without any earthquake resistant features. Keeping all these problems in view, the paper comprises two objectives: a) to assess the temporal occurrence of earthquakes and b) to record the spatial pattern of the earthquakes. The study is based on the data collected from various governmental institutions to provide additional impetus to the research. The methodologies adopted for data analysis are simple statistical technique like tabulation, frequency and averages. The result of the study shows that high vulnerable area to earthquakes is the one with structural deformities, higher concentration of population and building types and located towards the western part of the Himachal Himalaya. The proposed study is viable and relevant for future perspective of planning as one cannot avert the earthquakes but can always mitigate and reduce their impact.

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Introduction

The Indian subcontinent is world's most disaster prone country with its 54 percent of the land vulnerable to earthquake, 18 percent to the droughts, 15 percent to landslides, 8 percent to cyclones and 5 percent to floods. As far as India is concerned, it falls quite prominently on the global seismic belt, which runs in east west direction and is called Apline-Himalayan Belt. Four great earthquakes i.e., the 1897 Shillong earthquake, the 1905 Kangra earthquake, the 1934 Bihar-Nepal earthquake and 1950 Assam earthquake of magnitude in excess of 8 occurred in this belt in a short period of about 53 years. The 1905 Kangra earthquake was worse, in which 20,000 people died and extensive damage to property was reported. This earthquake was felt over a wide area extending laterally for a distance of about 300 km from Kangra to as far as Dehradun. From a seismic point of view Himachal Himalaya is considered to very sensitive as it falls in Zone IV and V as per the seismic zoning map of India. The zone V covers the areas liable to seismic intensity IX and above on the Modified Mercalli intensity scale. This is the most severe seismic zone and is referred to as the very high damage risk zone. The zone IV covers the areas liable to seismic intensity VIII and above on the Modified Mercalli intensity scale. This is the zone second in terms of severity to zone V and referred to as the high damage risk zone. The vulnerability atlas of India by Building Material and Technology Promotion Council (1997) shows that 32 per cent of the Himachal Himalaya is located in seismic intensity zone V while 68 per cent is located in seismic intensity zone IV. Not only does Himachal Himalaya fall within high Seismic bracket but around 69.5 percent houses are constructed of walls of clay mud, unburnt brick or random rubble masonry and 25.9 per cent with burnt brick houses are without any earthquake resistant features, which makes the region vulnerable to quivers of a shaking land. Himachal Himalaya has a history of earthquakes and experiences at least two strong earthquakes of intensity 6.0 and above on the Richter scale in the time span of 12 years. Ecologically being fragile and unstable in nature, slight disturbance in this region leads to adverse impacts to hazards resulting into vulnerability. Knowing these facts, an enquiry into the spatio-temporal earthquake in the Himachal Himalaya is essential to conceive.

Objectives of the Study

Keeping all these problems in view, the paper comprises of two objectives. They are a) to assess the temporal occurrence of earthquakes; and b) to record the spatial pattern of the earthquakes.

Database and Methodology

To fulfill the above stated objectives mainly secondary data have been used. These data have been collected from both national and state level government organizations. The national level

organization comprises of Indian Meteorological Department on the location of earthquakes their intensity, depth, date of occurrence and time of occurrence. The data for the geological structure of the study area and delineation of earthquake regions was collected from Indian Standards Institution and Geological Survey of India. The seismo tectonics, seismic micro-zonation and active fault studies carried out of Geological Survey of India was also scanned through. The seismotectonic Atlas of India and Its Environs (2000) was consulted to identify the seismic zones of Himachal Himalaya. The information and data generated by Building Materials and Technology Promotion Council of Ministry of Urban Affairs are taken into account towards the assessment of earthquake prone area and distribution of houses by predominant material of Roof and Wall and Level of Damage of risk in the Himachal Himalaya. The Wadia Institute of Himalayan Geology was referred to provide data on the occurrence of earthquake and seismicity status of the study area. The Landsat imagery showing shear zones, main lineament and ring shaped anomalies of Himachal Himalaya was referred to have a snapshot view. Apart from these, state level organizations include Himachal Himalaya state level disaster management authority and directorate of statistics and economics. Different layers such as geology, tectonic structure, density of population and types of houses along with the locational pattern of earthquakes have been developed using Arc GIS 9.0 software. Then all these layers have been simulated.

Result and Discussion

a) Temporal Occurrence of Earthquakes: The temporal occurrence of earthquakes in the Himachal Himalaya has to be better understood in two phases. The first phase is pre 1900 which hardly had published records on the occurrence of earthquakes because of lack of reporting and recording. The second phase is post 1900 which shows a better recording of the series of occurrences of earthquakes. The first and foremost record of the occurrence of earthquake was in 1809 in the Himachal Himalaya. The location of this earthquake was reported to be near Labrang in the district of Kinnaur. After the event of 1809, the second earthquake was occurred in the district of Chamba near Dalhousie and was of the same magnitude as in previous one with 5.5 on Richter scale. The third earthquake reported in 1856 near Ranhog in the district of Solan, while two other earthquakes after this occurred in the district of Shimla in 1858 and 1865. The effects of these earthquakes in terms of people killed and injured, property damage and changes in landforms are not available and lack documentation.

A more continuous and systematic record of earthquake occurrence was available from post 1900 onwards. This was due to better network of seismological observatories throughout India set up by the Indian meteorological department. But still there is absence of national seismological network of Indian metrological department in the Himachal Himalaya though a local network in this was started only after

mid-1960s. During 1900-2010, in 110 years, a total of 832 earthquakes have occurred in the Himachal Himalaya. The decade wise occurrence of earthquakes in the Himachal Himalaya reflects an increasing trend. Though there were decades when there is no single record on the occurrence of earthquake in the Himachal Himalaya viz., 1911-20, 1931-40, and 1951-60 respectively. This may be not necessarily mean that earthquakes did not occur during these decades but absence of records of geological events makes any assessment difficult.

The Table No. 1.0 below shows the record of occurrence of earthquakes in Himachal Himalaya. It is reflected that Himachal Himalaya prone to frequent number of earthquakes which shows an increasing trend. During 1900-2010, in the time span of 110 years a significant observation is that the time period before 1960s experienced meager number of earthquakes as compared to time period after 1960s. But here it is important to note that though the former time period has 6 earthquakes occurrences which is just 1 percent to the total but 1905 Kangra earthquake which is believed to be worst in Indian History and ranked first was occurred in this time span only. Though there are 4 more earthquakes of very high intensity more than 6.0 on Richter scale. This means that all the 5 earthquakes except one earthquake released greater amount of stress accumulated at larger time intervals. After 1960s almost 99 percent the total earthquakes have been occurred. In this also, around 65 percent of the earthquakes have been experienced only in 2001-2010 followed by 28.8 percent during 1991-2002. This large trail of earthquakes after 1960s do reflect a continuous release of stress accumulated at smaller time intervals. During this time interval only one earthquake i.e. 1975 Kinnaur earthquake was of very high intensity more than 6.0 on Richter Scale and another 13 earthquakes of high intensity on Richter Scale was recorded.

Table 1.0: Temporal Occurrence of earthquakes in Himachal Himalaya (1900-2010)

Decade	Number of Earthquakes
1900-1910	2
1911-1920	0
1921-1930	1
1931-1940	0
1941-1950	3
1951-1960	0
1961-1970	7
1971-1980	43
1981-1990	35
1991-2000	240

2001-2010	501
Total	832

Based on the Data from Indian Metrological Department, New Delhi, 2012.

The Himachal Himalaya generally experienced earthquakes of all magnitudes as is shown in Table 1.1 below. It is reflected through the table that 60 percent of the total earthquakes are of very low intensity followed by 19 percent of the earthquakes which are again of low intensity. This means that 79 percent of the total earthquakes are of low magnitude. Though moderate category is the one where earthquake of 4.1 to 5.0 magnitudes occurred and it represent 18 percent of the total. Remaining 3 percent of the earthquakes experienced are of high and very high intensity on Richter Scale.

Table 1.1 : Magnitude of earthquakes in the Himachal Himalaya

Magnitude of Earthquakes	Category	No. of Earthquakes	Percentages
Below 3.0	Very Low	506	60
3.1 – 4.0	Law	161	19
4.1 – 5.0	Moderate	146	18
5.1 – 6.0	High	13	02
Above – 6.0	Very High	06	01

Based on the Data from Indian Metrological Department, New Delhi, 2012.

On the basis of temporal occurrence of earthquakes and magnitude of earthquakes in the Himachal Himalaya it is said that Himachal Himalaya is prone to frequent earthquakes of magnitude less than 4.0 on the Richer Scale. The average number of earthquakes occurring Himachal Himalaya is 8 per year. The average number of high and very high magnitude earthquakes occurring in Himachal Himalaya is 1.7 in every 10 years. It means that 2 earthquakes of strong intensity occur in every 12 years in the Himachal Himalaya. There are 5 earthquakes of more than 6.0 magnitude on the Richter Scale as shown in Table 1.2 below. On an average, one earthquakes of more than 6.0 magnitude occurred in every 25 years. These six earthquakes are the 1905 Kangra earthquakes, the 1905 Kullu earthquakes, the 1945 Chamba earthquakes, the 1947 Chamba earthquakes, the 1951 earthquakes and 1975 Kinnaur earthquakes are most intense shown.

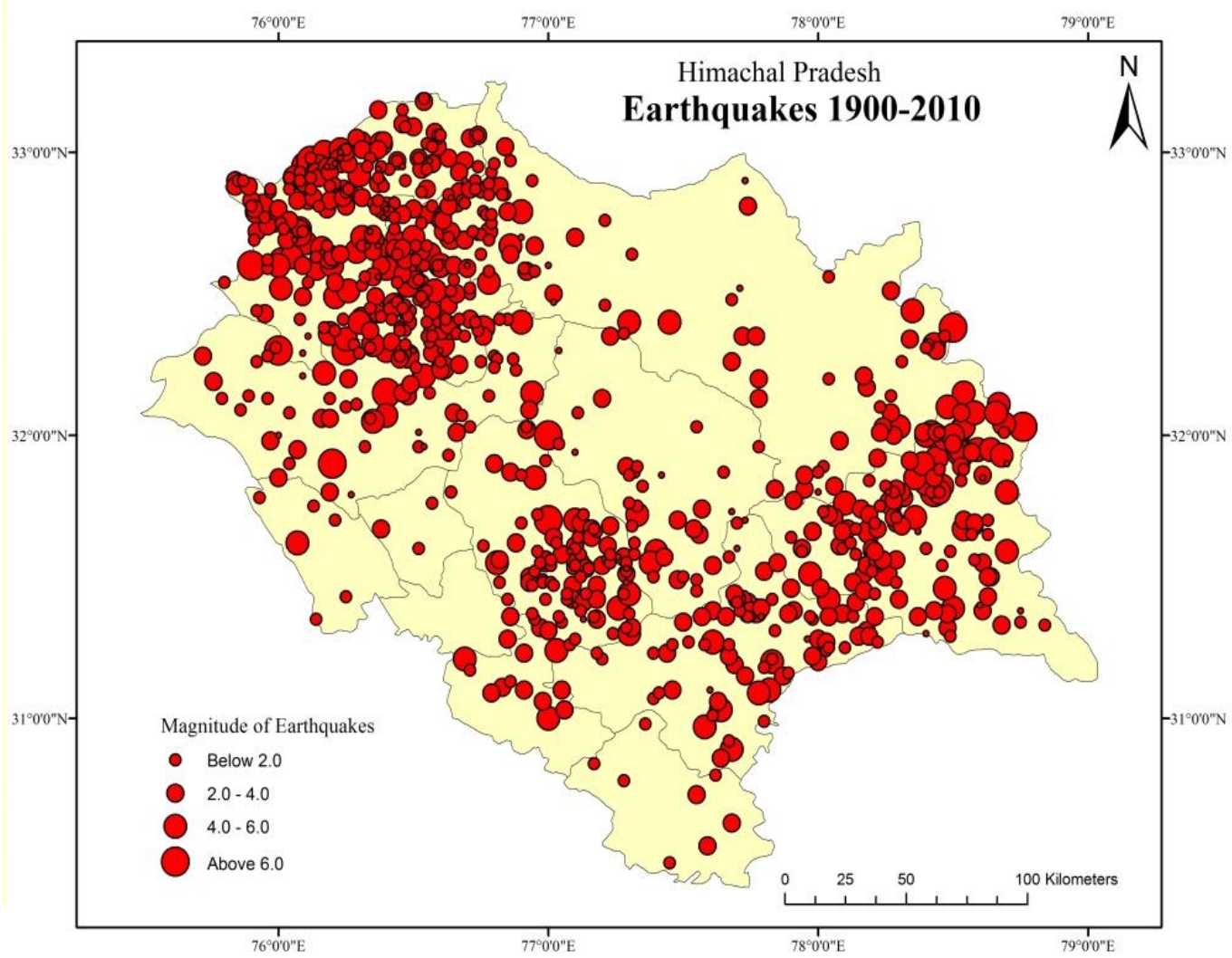
Table 1.2 : Earthquakes having magnitude 6.0 or more on Richter in Himachal Himalaya

Date of Occurrence	Magnitude	Location
04.04.1905	8.0	Karari Dal (Kangra)
28.02.1905	7.0	Karshing (Kullu)
22.06.1945	6.5	Minu (Chamba)
10.07.1947	6.2	Minu (Chamba)
22.09.1951	6.4	East of Dhan Kanda (Chamba)

19.01.1975	6.7	Kinnaur

Based on the Data from Indian Metrological Department, New Delhi, 2012.

b) Spatial Pattern of Occurrence of Earthquakes : We have seen in the temporal occurrence of the earthquakes that a total of 832 earthquakes have occurred in the Himachal Himalaya during 1900-2010. Out of this total, greater Himalaya experienced 274 earthquakes, lesser Himalaya witnesses 519 earthquakes and Shivaliks faced 39 earthquakes as shown in the Map 1.0 below.



It is seen from the map that 62 percent to the total earthquakes have been occurred in the lesser Himalaya and it is highly prone to earthquakes. The spatial pattern of earthquake occurrences in Himachal Himalaya at the district level reveals that the most common areas of earthquake occurrences are Chamba, Lahaul and Spiti, Kinnaur, Mandi, Shimla, Kangra and Kullu as shown in the Table 1.3 below.

Table 1.3 : District wise Occurrence Of Earthquakes In Himachal Himalay

District	Number of Earthquakes
Chamba	264
Lahaul and Spiti	129
Kinnaur	127
Mandi	95
Shimla	87
Kangra	56
Kullu	40
Solan	13
Sirmaur	08
Una	07
Hamirpur	03
Bilaspur	03
TOTAL	**832**

Based on the Data from Indian Metrological Department, New Delhi, 2012.

In one of the case studies carried out by Professor Arya, the damage potential of an earthquake of magnitude 8.0 on the Richter scale to the housing in Kangra district has been worked out by referring to what happened during the 1905 earthquake. The potential damage to various types of houses has been reckoned for a hypothetical earthquake with a magnitude of 8.0 on the Richter a scale based on the 1991 census. The following scene has emerged:

(a)	Completely collapsed houses	1,36,000
(b)	Those partly destroyed and with large and deep cracks which require reconstruction	2,63,000
(c)	Those without total or partial collapse but with large cracks. Some of these may have to be reconstructed but most require 15 to 20% of the cost of reconstruction.	9,16,000
(d)	Those with small cracks, repairable with evacuation	3,58,000
(e)	Those with only fine cracks or no damage	1,43,000
(f)	Number of potential deaths	65,000

Economic losses may amount to Rs. 5000 Crores besides the amount spent on relief and temporary shelter (Price index of 1997).

If, on the other hand, all such houses were initially built with earthquake resistant feature in kutcha as well as Pucca houses, the damage scene will change as follows:

Total collapsed houses	8,300
Destroyed with partial collapse	95,000
Deep large cracks	3,12,400
Small cracks	6,48,000
Estimated loss of human lives	12,000

Economic loss estimated is reduced to Rs. 1960 Crores. Besides the cost of relief and temporary shelter will also be reduced to one third of the above. The same benefit of seismic resisting features can be derived in the case of existing housing pattern in all the districts, if the existing unsafe houses are refitted to upgrade their seismic safety. Post construction refitting will, however, cost 2.5 to 3 times more than seismic resisting features in new constructions of similar types. Thus, large losses of totally damaged houses can be minimized and loss of life reduced to less than one fifth, only if refitting of existing houses and buildings is adopted as a government strategy for earthquake disaster prevention.

Conclusion

Earthquakes neither are preventable nor predictable. It is commonly said that the earthquakes do not kill people but it is the building that do. Himachal Himalaya is one of the seismically and tectonically active areas. Himachal Himalaya has historical record of numerous earthquakes. High magnitude earthquakes that is beyond 6.0 and above on the Richter scale have occurred in 1905, 1945, 1947, 1951 and 1975 in the Himachal Himalaya. Inspite of high vulnerability of the Himachal Himalaya to the earthquakes, the housetypes are built without any earthquake resistant feature. The basic need is to build better and safer dwellings incorporating earthquakes resistance parameters. It is estimated about 10 percent additional expenditure on the total budgeted cost of the house can make the dwelling safe from earthquakes (Thakur 2006). It is necessary that the government take into account the earthquake history of the Himachal Himalaya to ensure an appropriate reconstruction strategy. It is only by reducing vulnerability of the people through development that mitigation of earthquake can occur. Understanding spatial and temporal occurrence of earthquakes and parameters of physical and socioeconomic vulnerability can help formulate people and place sensitive plans and policies. This would go a long way towards- mitigating earthquake.

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